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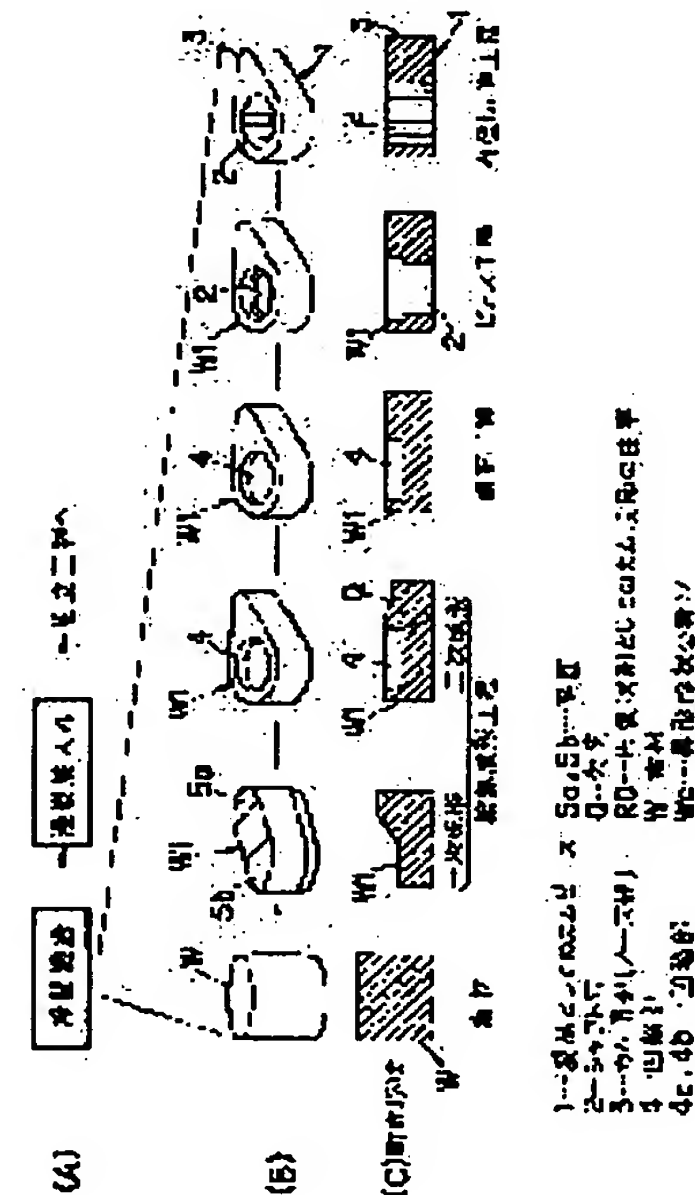
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(54) METHOD FOR MANUFACTURING CAM PIECE FOR BUILT-UP CAM SHAFT

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for manufacturing a cam piece which is based on cold forging and has excellent accuracy of form.

SOLUTION: This method for manufacturing a cam piece includes the steps of: swaging a material W and forging the material W to form a contour of a cam piece 1, i.e., contour forming step; forming a shaft hole 2 in the center part of the intermediate formed product W1 by blanking, i.e., piercing step; and ironing the inner diameter for finishing the inner peripheral face of the shaft hole 2, i.e., inner diameter ironing step. Shaping in each step is carried out by cold treatment. The shape of the intermediate formed product W1 prepared in the primary forming in the contour forming step is such that, in faces corresponding to one side face of the cam piece 1, a face 5a on a cam top part 3 side is parallel to but is different in level from and has a larger height than a face 5b located opposite to the face 5a and the thickness as the intermediate formed product W1 gradually increases toward the cam top part 3 side.



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CLAIMS

[Claim(s)]

[Claim 1] The contour-forming process which sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment As a process configuration by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece in the middle of the material in the above-mentioned contour-forming process The manufacture approach of the cam piece for collapsible cam shafts characterized by the thickness dimension as a material serving as a configuration increased gradually toward a cam crowning side.

[Claim 2] The above-mentioned contour-forming process is divided into the primary forming cycle and the secondary-forming process following it at least. The middle Plastic solid after primary shaping By being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece The manufacture approach of the cam piece for collapsible cam shafts according to claim 1 characterized by the thickness dimension as a middle Plastic solid serving as a configuration increased gradually toward a cam crowning side.

[Claim 3] The contour-forming process which sets a material in the thickness

direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment The manufacture approach of the cam piece for collapsible cam shafts characterized by forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the material thrown into the above-mentioned contour-forming process at the part which should serve as a cam crowning of cam piece at least.

[Claim 4] The manufacture approach of the cam piece for collapsible cam shafts according to claim 3 characterized by giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should become the material thrown into the above-mentioned contour-forming process with the cam crowning of cam piece at least.

[Claim 5] The material thrown into the above-mentioned contour-forming process is the manufacture approach of the cam piece for collapsible cam shafts according to claim 4 characterized by making cam piece and an analog and setting the ratio of the major axis of the material, and a minor axis as the same ratio as cam piece.

[Claim 6] The manufacture approach of the cam piece for collapsible cam shafts according to claim 1 to 5 which makes the multi-process forging press method of construction which comes to contain the above-mentioned contour-forming process, a pierced earring process, and a bore cover-printing process a basic method of construction.

[Claim 7] The above-mentioned material is the manufacture approach of the cam piece for collapsible cam shafts according to claim 1 to 6 characterized by performing carburization processing after the cold treatment which is low-carbon steel or the alloy steel of low carbon, and comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process.

[Claim 8] The contour-forming process which sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, The pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, The bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing is included. The manufacture approach of the cam piece for collapsible cam shafts characterized by performing shaping at each

above-mentioned process with the multistage type forging machine of a horizontal *** type as a cold treatment in the condition of having placed the cam crowning side upside down, at least, respectively.

[Claim 9] The above-mentioned contour-forming process is the manufacture approach of the cam piece for collapsible cam shafts according to claim 8 characterized by including the primary forming cycle and the secondary-forming process following it at least.

[Claim 10] The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 or 9 characterized by performing conveyance of the middle Plastic solid between each process in the condition of similarly having placed the cam crowning side upside down, with shaping at each above-mentioned process.

[Claim 11] It is set up so that the direction of the profile configuration of the middle Plastic solid fabricated at the back process rather than the profile configuration of the middle Plastic solid fabricated at the before process among two adjacent processes may become large. The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 to 10 characterized by pushing in and inserting after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree, in case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process.

[Claim 12] The manufacture approach of the cam piece for collapsible cam shafts according to claim 11 characterized by only the specified quantity making the center-of-gravity location of the lump [carve] by the side of a back process have offset to the upper part side beforehand to the center-of-gravity location of the lump [carve] by the side of a last process as a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process.

[Claim 13] The manufacture approach of the cam piece for collapsible cam shafts according to claim 11 characterized by only the specified quantity moving caudad the center-of-gravity location of the middle Plastic solid in the process in which a middle Plastic solid is conveyed at a back process from a last process as a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process.

[Claim 14] And a long picture coil strip is supplied to the initial process of a multistage type forging machine. the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- It is the manufacture approach of the cam piece for collapsible cam shafts which was made to

perform with a multistage type forging machine to cutting of the material from a coil strip. The coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by ****ing the cam top equivalent section outside may turn down. The manufacture approach of the cam piece for collapsible cam shafts according to claim 8 to 13 characterized by supplying the coil strip to the above-mentioned multistage type forging machine with rewinding.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the manufacture approach of suitable cam piece to unify mutually the hollow-like shaft formed especially separately and the cam piece which is a forging by diameter expansion (expansion) processing of a shaft about the manufacture approach of the cam piece for collapsible cam shafts which will function as a main element of an internal combustion engine's valve gear system, and consider as a collapsible cam shaft.

[0002]

[Description of the Prior Art] The forging besides a sinter is used as cam piece (called a cam lob (cam lobe) or a cam lobe) of a collapsible cam shaft, and it is used, after using the high-carbon steel of S70C and S55C as a material and performing hardening processing after forging, in order to secure surface hardness, especially in being the cam piece of a forging. And as for the cam piece of a forging, it is common to be fabricated by hot forging which was excellent in the moldability as shown in JP,9-276976,A and JP,9-280013,A.

[0003] On the other hand, although a high precision will be required of the dimension

of a shaft, and the inside diameter of cam piece since he is trying for a collapsible cam shaft to guarantee the press fit reinforcement and mutual attachment precision of cam piece and a pipe-like shaft by both press fit cost, the precision prescribe as components is not fully securable in the case of the forging cam piece of the high-carbon steel fabricated with hot forging because of the dimensional change by generating or the heat shrink of the scale at the time of hot forging. Therefore, it is necessary to finish-machine cutting or cold forming etc. which is represented by broaching for inside diameter reservation of cam piece at another process, and the cost rise by the increment in a routing counter and the increment in the management man day of a middle inventory is obliged.

[0004] Moreover, in the case of the forging cam piece of high-carbon steel, in order to secure surface hardness, it is necessary to perform hardening processing but, and It is impossible to make the baking crack at the time of hardening there be nothing as particulars of the quality of the material itself. It burns in order to prevent beforehand the breakage at the time of the press fit assembly which considers the baking crack as a cause, and generating with insufficient insertion pressure, and the sorting process of inspection of the existence of crack generating or a baked crack article becomes indispensable, and the cost rise by the increment in a routing counter becomes much more remarkable with the fall of the yield.

[0005] Then, the manufacture approach of the cam piece based on cold forging replaced with hot forging is proposed as the patent No. 2767323 official report.

[0006] However, if deformation is not made small enough in case it is not only easy to generate defects, such as under-fill, but [since the forging moldability (fluidity of material meat) is low,] plastic deformation is carried out from a material to a required product configuration compared with hot forging, the shaping load over a mold will become large, wear of a mold becomes intense and cold forging tends to cause the early life of a mold.

[0007] Since it becomes the form where only an almost equal amount bulges in the direction of a periphery when a solid cylinder-like material is set on shaft orientations and is especially compressed into them Even if it is comparatively easy to fabricate in a simple circle configuration or the configuration near it a cam piece configuration which compounded the radii section (nose section) which should turn into a circular base circle and a cam crowning more remarkable than this with small radius of curvature -- a breath -- and it is difficult to fabricate so that there may be no generating of under-fill. Therefore, it is necessary to make [many] a processing routing counter in order to carry out slight amount [every] plastic deformation and to

fabricate from a material to a product configuration, and floor to floor time also becomes long and a forging facility will not only become large-sized and expensive, but it tends to cause the fall of productivity.

[0008] This invention is made paying attention to such a technical problem, and though, it offers the approach which enabled it to manufacture the highly precise cam piece which moreover does not have generating, such as under-fill, at a smaller routing counter, on the assumption that cold forging.

[0009]

[Means for Solving the Problem] The contour-forming process which invention according to claim 1 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment As a process configuration by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece in the middle of the material in the above-mentioned contour-forming process It is characterized by the thickness dimension as a material serving as a configuration increased gradually toward a cam crowning side.

[0010] Moreover, invention according to claim 2 materialized the publication of claim 1 more, and the above-mentioned contour-forming process is divided into the primary forming cycle and the secondary-forming process following it at least. And the middle Plastic solid after primary shaping is characterized by the thickness dimension as a middle Plastic solid serving as a configuration increased gradually toward a cam crowning side by being a configuration with a level difference so that the direction of the part by the side of a cam crowning may become high, though the part by the side of a cam crowning, it, and the part of the opposite side are parallel to the side face of another side among the fields equivalent to one side face of cam piece.

[0011] in this case -- as a material -- for example, although it is cylindrical (a solid -- cylindrical), when promoting the plastic flow of an ingredient much more and preventing defects, such as under-fill, it is desirable to use the configuration of cam piece and the material of an analog which are a final product.

[0012] Therefore, although the cam piece which has a shaft hole by roughly dividing

and passing through a contour-forming process, a pierced earring process, and a bore cover-printing process will be fabricated in invention given in these claims 1 and 2 As a middle Plastic solid after primary shaping which is a process configuration in the middle of the material in a contour-forming process If it is the configuration which a thick dimension increases gradually toward a cam crowning side, it will come to be promoted in the phase of secondary forming following subsequent forging shaping or subsequent primary shaping, the material flow, i.e., the plastic flow, in the major-axis direction of cam piece. Especially, it comes to act effectively after under-fill generating preventing by the side of a cam crowning.

[0013] The contour-forming process which invention according to claim 3 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, While including the pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, and the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing and performing shaping at each above-mentioned process as a cold treatment It is characterized by forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the part which should serve as a cam crowning of cam piece at least at the material thrown into the above-mentioned contour-forming process.

[0014] Therefore, although the cam piece which has a shaft hole by passing through a contour-forming process, a pierced earring process, and a bore cover-printing process at least like the above will be fabricated in this invention according to claim 3 If the crowning of the cam piece and the circular section of equivalent curvature are beforehand formed in the part which should serve as a cam crowning at least among materials, it will become advantageous, when fabricating the big cam piece of shaping of the profile of the cam piece by cold forging, especially the difference of a major axis and a minor axis.

[0015] Invention according to claim 4 is characterized by giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should serve as a cam crowning of cam piece at least at the material thrown into a contour-forming process on the assumption that the publication of claim 3.

[0016] Here, the above-mentioned aperture angle means the include angle which two tangents make, when the tangent cam of the configuration where the base circle of cam piece and the radii section of a cam crowning smaller than this were connected with two tangents which both share is assumed.

[0017] In this case, it is desirable for the material according to claim 5 thrown into a

contour-forming process to make cam piece and an analog like, and to set the ratio of the major axis of that material and a minor axis as the same ratio as cam piece.

[0018] Therefore, in invention given in these claims 4 and 5, the whole part or whole material which is equivalent to a cam crowning at least among materials is exactly formed in the configuration and analog of the cam piece which is a final product beforehand, but becomes easier [shaping of the profile of the cam piece by cold forging].

[0019] In invention given in above-mentioned claims 1-5 here, it is desirable on a productivity drive to make into a basic method of construction the method of construction by the multi-process forging press method of construction, i.e., a multistage type cold-forging machine according to claim 6, which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process like in any case.

[0020] Moreover, it is desirable to perform carburization processing like, after the cold treatment which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process, using low-carbon steel or the alloy steel of low carbon as a material, after [according to claim 7] being premised on one publication of claims 1-6, after moldability improving between the colds.

[0021] The contour-forming process which invention according to claim 8 sets a material in the thickness direction of cam piece, and carries out forging shaping of the profile configuration of cam piece, The pierced earring process which pierces and fabricates a shaft hole in the center section of the middle Plastic solid after contour forming, It is characterized by including the bore cover-printing process which carries out finishing shaping of the inner skin of a shaft hole at the shape of toothing, and performing shaping at each above-mentioned process with the multistage type forging machine of a horizontal **** type as a cold treatment in the condition of having placed the cam crowning side upside down, at least, respectively.

[0022] In this case, a primary forming cycle and the secondary-forming process following it according to claim 9 may be included at least by the above-mentioned contour-forming process like.

[0023] Moreover, it is more desirable to perform conveyance of the middle Plastic solid between each process with shaping at each process like in the condition according to claim 10 of similarly having placed the cam crowning side upside down.

[0024] therefore, in these invention according to claim 8 to 10 If it inserts for conveying a middle Plastic solid at a back process from a last process, and the metal mold by the side of a process (dice) carving after that, and being crowded (it also

being called in play SHON (impression)) the cam crowning of a middle Plastic solid, and the cam top equivalent section of the lump [carve] which manages shaping of that -- a self ROKETO function or an automatic alignment function -- demonstrating -- an early stage to both -- agreeing -- carving -- the middle Plastic solid within a lump -- being the so-called -- it will roll and a phenomenon will be prevented. Since this is exactly that the location of a middle Plastic solid inclines toward the cam crowning side to the carve lump, and allocation of ingredient (material meat) volume inclines toward the cam crowning side, priority is given to a cam crowning side, ingredient volume is distributed, the ingredient fullness by the side of the cam crowning is promoted, and when preventing the thickness deviation and under-fill by the side of the most important cam crowning on a function, it comes to act very effectively.

[0025] Invention according to claim 11 as a premise of one publication of claims 8-10 It is set up so that the direction of the profile configuration of the middle Plastic solid fabricated at the back process rather than the profile configuration of the middle Plastic solid fabricated at the before process among two adjacent processes may become large. In case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process, it is characterized by pushing in and inserting, after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree.

[0026] More specifically as a means according to claim 12 to push in and insert a middle Plastic solid like after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process Only the specified quantity makes the center-of-gravity location of the lump [carve] by the side of a back process offset to an upper part side beforehand to the center-of-gravity location of the lump [carve] by the side of a last process, or like a publication to claim 13 As a means to push in and insert a middle Plastic solid after making a cam crowning agree beforehand in the cam top equivalent section of the lump [carve] by the side of a back process, only the specified quantity shall move caudad the center-of-gravity location of the middle Plastic solid to a back process in the process in which a middle Plastic solid is conveyed, from a last process.

[0027] Therefore, in case the middle Plastic solid from a last process is inserted in these claims 11-13 to a carve lump of a back process by invention of a publication, it carves with the cam crowning of the middle Plastic solid, and the cam top equivalent section by the side of a lump comes to agree autonomously.

[0028] After being premised on one publication of claims 8-13, invention according to

claim 14 And a long picture coil strip is supplied to the initial process of a multistage type forging machine. the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- The coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by carrying out the cam top equivalent section outside may turn down, when a multistage type forging machine performs to cutting of the material from a coil strip. It is characterized by supplying the coil strip to the above-mentioned multistage type forging machine with rewinding.

[0029] Namely, a coil strip is set to an uncoiler so that the rewinding starting position of the coil strip which rolled round by ****ing the cam top equivalent section outside may turn up. When premised on supplying the coil strip to the above-mentioned multistage type forging machine with rewinding, As for the sense of the material cut from the coil strip, a cam crowning side serves as facing up. Since it cannot but become the posture in which the ideal posture in which a cam crowning side which was described previously serves as facing down is reverse, in invention according to claim 14, it is considered beforehand that the rewinding starting position of a coil strip turns down.

[0030] Therefore, not sections but a coil strip is directly supplied to a multistage type forging machine, and in this invention according to claim 14, when premised on carrying out with a multistage type forging machine to the material [itself] cutting, the sense of the material immediately after cutting becomes what was in agreement with the shaping posture in each process, and after that a forging process accelerates, it will become more desirable.

[0031]

[Effect of the Invention] According to invention given in claims 1 and 2, it is premised on the manufacture approach which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process at least. Since it is the configuration which a thick dimension increases gradually toward a cam crowning side as a configuration of the middle Plastic solid after primary shaping which is a process configuration in the middle of the material in a contour-forming process, while the material flow of the major-axis direction of cam piece is promoted Since the rate of flow of the material meat by the side of a cam crowning becomes large relatively and the cam crowning side is filled promptly, there is effectiveness which can be fabricated easily without being accompanied by generating of under-fill etc. promptly [crowning / with small radius of curvature / cam]. Moreover, a shaping load required for making a cam crowning side filled with material meat is mitigated, it combines with

reduction of the load of metal mold, and the reinforcement can be attained now.

[0032] By forming beforehand the crowning of the cam piece, and the circular section of equivalent curvature in the part which should serve as a cam crowning of cam piece at least at the material thrown into a contour-forming process according to invention according to claim 3 Shaping of the profile configuration at the time of carrying out cold-forging shaping of the big cam piece of especially the difference of a major axis and a minor axis, i.e., the cam piece with the big amount of cam lifts, becomes easy. There is effectiveness which can be easily fabricated by the routing counter small to a cam crowning especially with small radius of curvature, and also there is an advantage which combines with reduction of the load of metal mold like the above, and can attain the reinforcement.

[0033] By giving the aperture angle equivalent to the crowning of the cam piece beforehand to the part which should become the material thrown into a contour-forming process with the cam crowning of cam piece at least according to invention according to claim 4 In addition to the same effectiveness as invention according to claim 3, shaping of the profile configuration of cam piece becomes still easier, and can attain reduction of the further routing counter, and the reinforcement of metal mold, and also like especially the publication to claim 5 If the material is making cam piece and an analog and is set as the ratio as cam piece with the same ratio of the major axis of the material, and a minor axis, the above-mentioned effectiveness will become more remarkable.

[0034] Since the multi-process forging press method of construction which comes to contain a contour-forming process, a pierced earring process, and a bore cover-printing process also in publication [which / of claims 1-5] is made into the basic method of construction according to invention according to claim 6, while being able to attain the desired end by the necessary minimum routing counter, continuous molding becomes possible, and it becomes possible to aim at cost cut by reduction of a routing counter, and the dissolution of a middle inventory, and improvement in productivity.

[0035] Since the low-carbon steel which was excellent in the moldability between the colds as a material, or the alloy steel of low carbon is used according to invention according to claim 7, it becomes possible to fabricate in a cam piece configuration at a stretch from a material with cold forging, and cold forming of the profile configuration of cam piece and cold forming of a bore configuration can be performed now at the continuous process, and the cost cut by reduction of a routing counter and the dissolution of the inventory between processes is attained.

[0036] Since carburization hardening processing is performed and he is trying to secure required surface hardness after cold-forging processing moreover, compared with the hardening article of high-carbon steel, the hardness distribution differs and, as for the cam piece to which carburization hardening was performed, becomes what has a low internal degree of hardness. And although an impact load will be received in case cam piece inserts a mandrel in the shaft used as the other party and diameter expansion association is carried out, it acts advantageously that the internal hardness of cam piece is low as mentioned above, and it becomes possible for shock resistance to improve as a result and to prevent generating of the crack of the cam piece at the time of diameter expansion.

[0037] According to invention according to claim 10, further according to invention given in claims 8 and 9 by shaping at each above-mentioned process being performed by the multistage type forging machine as a cold treatment in the condition of having placed the cam crowning side upside down, respectively Since conveyance of the middle Plastic solid between each process is also performed in the condition of having placed the cam crowning side upside down, if even insertion makes the middle Plastic solid conveyed from the last process a carve lump of a back process The cam crowning of a middle Plastic solid and the cam top equivalent section of the lump [carve] which manages shaping of that will agree immediately. It carves.

Consequently, not to mention the so-called thing [that it rolls and a phenomenon can be prevented] of the middle Plastic solid within a lump Since it is exactly that the location of a middle Plastic solid inclines toward the cam crowning side, and inclines toward a cam crowning side substantially to a carve lump from the stage when ingredient allocation is early The ingredient fullness by the side of a cam crowning is promoted much more, prevents certainly the thickness deviation and under-fill by the side of the most important cam crowning on a function, and can contribute now to the forging progression in quality greatly.

[0038] In case a middle Plastic solid is pushed in and inserted to a carve lump of the dice of a back process according to invention according to claim 11 Make it push in and insert, after carving the cam crowning beforehand and making the cam top equivalent section by the side of a lump agree, and according to invention given in claims 12 and 13 [whether only the specified quantity makes the center-of-gravity location of the lump / carve / by the side of a back process offset to an upper part side beforehand as the concrete means to the center-of-gravity location of the lump / carve / by the side of a last process, and] Or since it is made only for the specified quantity to move caudad the center-of-gravity location of the middle Plastic solid to a

back process in the process in which a middle Plastic solid is conveyed, from a last process It carves with the cam crowning of the middle Plastic solid, the cam top equivalent section by the side of a lump comes to agree autonomously, the ingredient fullness effectiveness by the side of a cam crowning is promoted much more, and there is an advantage which can prevent more certainly the thickness deviation and under-fill by the side of a cam crowning.

[0039] And in charge of supplying a long picture coil strip to a multistage type forging machine directly according to invention according to claim 14 -- the configuration of cam piece, and abbreviation -- a variant configuration with the cross-section configuration of an analog -- Since it considers beforehand that it is in agreement with the posture to which the sense of the material after the cutting made the above-mentioned cam crowning facing down The configuration precision can be further stable, the ingredient fullness by the side of a cam crowning being promoted further, and preventing the thickness deviation and under-fill by the side of a cam crowning, and also reduction of a forging routing counter and reduction of a manufacturing cost can be aimed at compared with the case where sections are used as a material.

[0040]

[Embodiment of the Invention] Drawing 1 -9 show the gestalt of more desirable implementation of the manufacture approach of the cam piece concerning this invention.

[0041] As shown in (A) of drawing 1 , with the gestalt of this operation, it is premised on using low-carbon steel or the alloy steel (for example, SCr420H material whose content of Carbon C is 0.2%) of low carbon as a material W of the cam piece 1 about the collapsible cam shaft which will be assembled by passing like cold forging, carburizing, and an erector. Since the ingredient of low carbon has the good moldability between the colds, it becomes possible [fabricating in a cam piece configuration at a stretch from Material W with cold forging]. Consequently, cold forming for fabricating cold forming and the bore configuration for fabricating the profile configuration of the cam piece 1 can be performed now at the process of continuation so that it may mention later, and the cost cut by reduction of a routing counter and the dissolution of the inventory between processes is attained.

[0042] the process of cold forging is subdivided still as shown in (B) of drawing 1 , and (C) -- having -- **** -- a solid -- with the contour-forming process fabricated in the configuration of the cam piece 1 with the material [being cylindrical (cylindrical)] W The bore cover-printing process which carries out finishing shaping is included in the

variant configuration like for example, a hole spline configuration about the correction process which prepares the thickness dimension of the cam piece 1, the pierced earring process which performs punching processing of the shaft hole 2 formed in the center section of the cam piece 1, and the inner skin of the shaft hole 2. If it is the routing counter of only this, it will become possible to carry out continuous molding of all the processes from a contour-forming process to a bore cover-printing process with a high-speed multi-process forging press machine (multistage type cold-forging machine), and the improvement and the cost cut of productivity by shortening of the cycle time can be aimed at now.

[0043] While the contour-forming process is further divided into the primary forming cycle and the secondary-forming process, setting the cylinder-like material W in the direction of an axial center in a primary forming cycle, setting an ellipse configuration or in the shape of an abbreviation gold coin and carrying out lump deformation Owner stage shaping of the part equivalent to the top face of middle Plastic solid W1 which is a process configuration while [the] having deformed, i.e., one side face of the cam piece 1, is carried out at a configuration including two flat surfaces 5a and 5b. It fabricates in the configuration which the thickness increases gradually toward the part which should serve as the cam crowning (nose section) 3 of the cam piece 1 so that it may mention later.

[0044] Moreover, at a secondary-forming process, while it sets in order to carry out flattening of middle Plastic solid W1 by which owner stage shaping was carried out further in a primary forming cycle, and preparing a profile configuration in the configuration of the cam piece 1, printing pressure shaping of the cavity 4 is carried out at the part which should serve as the shaft hole 2. Although the cavity 4 in this process does not necessarily need to be fabricated, when lessening the field which should serve as a scrap in the case of pierced earring processing which distributes material meat and is later mentioned from an early stage as much as possible, it acts effectively.

[0045] When a contour-forming process is finished with this secondary-forming process, Under-fill Q may occur still more in some middle Plastic solids W1. So, at the correction process following a contour-forming process, it sets in the thickness direction, preparing further the profile configuration of middle Plastic solid W1, and it sets right so that Under-fill Q may be lost.

[0046] The part in which the cavity 4 was previously formed among middle Plastic solids W1 is pierced by the shear method of construction by making this into a prepared hole, and the shaft hole 2 is fabricated at a pierced earring process.

Furthermore, in a bore cover-printing process, ironing is performed with press fit of a mandrel about the shaft hole 2, and the inner skin of the shaft hole 2 is finished in the shape of toothing with the gestalt like a hole spline.

[0047] Although drawing 1 shows the cylinder-like thing as a material W, it is more desirable to use the so-called material Wc of the profile configuration of the cam piece 1 which is a product as shown, for example in drawing 2, and the variant configuration which makes an analog. The material Wc of such a variant configuration can be fabricated by the continuous casting process as shown in drawing 3. That is, casting shaping is carried out as a cylindrical material Wn of a variant configuration by drawing out with through the die 13 by which forced cooling was carried out with the cooling system 12 according the molten metal in a holding furnace 11 to water etc., and drawing out with equipment 14. In addition, this kind of technique is well-known at JP,5-104209,A etc.

[0048] Although it is also possible to cut from a cylindrical material in a predetermined dimension at a last process beforehand, and to supply this to the contour-forming process shown in drawing 1 irrespective of whether Material W (or Wc) is a cylinder-like thing or it is the thing of a variant configuration, it is desirable on process compaction and a middle inventory dissolution to supply a cylindrical material to a multi-process forging press machine directly, to cut at the initial process, and to supply to the contour-forming process which is a back process as it is. Moreover, what was drawn out and fabricated is made into a variant configuration in roll forming etc., casting as a method of fabricating the material Wc of the above-mentioned variant configuration in the shape of the round bar besides the approach of fabricating directly by the above-mentioned continuous casting process, and you may make it supply this to a cutting process.

[0049] since there be little ingredient migration in the major axis direction of the cam piece 1 at the time of forging and it end when a material Wc be beforehand make into a variant configuration as mentioned above, it be large, the cam piece 1 of cam lifts with a large difference, i.e., amount, of a major axis and a minor axis, or the cam piece 1 the cam crowning 3 sharpened in a peace much more can be fabricate easily, and also when lessen the routing counter within a contour forming process, it act effectively. And when deformation until it becomes the configuration of the cam piece 1 needed from a material configuration decreases, the load of metal mold is mitigated and it becomes advantageous also on the reinforcement. Therefore, it is also possible to be able to make deformation in a primary forming cycle small much more, to mix the primary forming cycle and secondary-forming process of drawing 1 substantially with

the magnitude of the cam piece 1 etc., and to form a contour-forming process into 1 process.

[0050] Although the material W_c of the variant configuration shown in (A) of drawing 2 is defined by the radius of curvature R_0 as the circular section of the part equivalent to the cam crowning (nose section) 3, the aperture angle θ_0 of the cam crowning 3, and the ratios D_0/d_0 of a major axis D_0 and a minor axis d_0 . It is desirable to become the same as the ratios D_1/d_1 of those radius of curvatures R_0 and the radius of curvature R_1 of the cam crowning 3 of the cam piece 1 which is a final product configuration, respectively as shown in this drawing (B) of the value of D_0/d_0 besides the value of the aperture angle θ_0 , the aperture angle θ_1 and a major axis D_1 , and a minor axis d_1 . However, when all conditions must have been fulfilled from the constraint on shaping of a shaping limitation, a capacity rating limitation, etc., it is made to make as priority the configuration of Material W_c , and the configuration of the cam piece 1 which is a product in agreement in order of the radius of curvature R_0 of (1) cam crowning, the aperture angle θ_0 of (2) cam crowning, and the ratios D_0/d_0 of the (3) major axis D and a minor axis d . In addition, priority here corresponds with the ranking of the difficulty of configuration precision **** in the case of fabricating the cam piece 1 from the cylinder-like material W in the contour-forming process of drawing 1.

[0051] Here, when the tangent cam of the configuration connected with two tangents with which both share the base circle of the cam piece 1 and the radii section of the cam crowning 3 smaller than this as the aperture angle θ of the above-mentioned cam crowning 3 as shown in drawing 2 is assumed, the include angle which two tangents make is said.

[0052] In the middle of the material W which finished primary shaping at the contour-forming process of drawing 1, the process configuration W_1 , i.e., a middle Plastic solid A_s shown also in drawing 4. So that the direction of partial 5a by the side of the cam crowning 3 may become high, though partial 5a, it, and partial 5b of the opposite side which are equivalent to the cam crowning 3 side among the fields equivalent to one side face of the cam piece 1 which is a product are parallel to the side face of another side. The thickness dimension as middle Plastic solid W_1 serves as a configuration increased gradually toward the cam crowning 3 side by being a configuration with a level difference between these two flat surfaces 5a and 5b. When this thought is applied to the material W_c of the variant configuration described previously, it means that both the cross sections in each same include-angle α^{**} of middle Plastic solid W_1 which is a process configuration in the middle of Material W_c

as shown in drawing 5 , and the product slack cam piece 1 are the same.

[0053] It is unsymmetrical and material volume is secured in the thickness direction as a configuration of the middle Plastic solid W1 to a product configuration like the above-mentioned cam piece 1 by which volume inclines toward the one direction, and the part equivalent to the cam crowning 3 is made brought near and filled with an ingredient, equalizing a thickness dimension gradually afterwards. The flow or plastic flow of an ingredient by the side of the cam crowning 3 it is easy to become inadequate [fullness of an ingredient] by carrying out like this in many cases [crowning] is promoted, and while shaping of the cam piece 1 with which the cam crowning 3 sharpened much more is attained, the percent defective by under-fill etc. is improved sharply. Of course, by promoting a flow of an ingredient, the load which shaping takes will be mitigated and it can contribute also to the reinforcement of metal mold.

[0054] Moreover, if middle Plastic solid W1 which makes Materials W or Wc a former configuration as mentioned above serves as a configuration with a level difference including two flat surfaces 5a and 5b, the posture of middle Plastic solid W1 in the secondary-forming process following a primary forming cycle will be stable, and it will act effective in especially generating prevention of under-fill. For example, if middle Plastic solid W1 serves as a configuration with the level difference which includes two parallel fields 5a and 5b mutually as shown in drawing 6 Deform plastically correctly in the shape of a cross-section rectangle in the case of secondary forming set by the dice 6 and punch 7, and after that under-fill etc. prevents [generating], that of ***** is received advantageously. When it does not have the level difference which includes two parallel fields 5a and 5b mutually, it is in the middle of shaping, and as shown in drawing 7 , middle Plastic solid W1 falls over, a phenomenon arises, it deforms cross-section trapezoidal shape or in the shape of a rhombus, and generating of Under-fill Q etc. is obliged.

[0055] In the secondary-forming process of the contour-forming process shown in drawing 1 , the cavity 4 is fabricated for making it function as a prepared hole which serves as an origin of punching in the case of pierced earring processing at a back process, while bringing near an ingredient by the part which should serve as the cam crowning 3 positively. On the other hand, if coincidence shaping of the cavity 4 is carried out, generating of the unevenness of thickness will become unescapable with the ingredient upheaval by the periphery. Then, the correction process following a contour-forming process is performed in order to correct the unevenness of this thickness.

[0056] In a pierced earring process, after piercing and fabricating the shaft hole 2, the configuration like a hole spline is made to the shaft hole 2 by inserting the mandrel of the shape of a pin of the same cross-section configuration as a shaft etc. in the shaft hole 2 at a bore cover-printing process, and performing ironing. This obtains the cam piece 1 as a product as shown in drawing 8 .

[0057] In this way, as shown in drawing 1 , carburization hardening is performed to the cam piece 1 which finished plastic working, and required surface hardness is secured. That is, since a surface carbon content is insufficient of Material W or the Wc itself unlike high-carbon steel as stated previously, carburization processing at a back process is needed. As the cam piece 1 to which carburization hardening was performed is shown in drawing 9 , compared with the hardening article of high-carbon steel, the hardness distribution differs and becomes what has a low internal degree of hardness.

[0058] Finally, although the cam piece 1 will be combined with the shaft used as the other party, in case a mandrel is inserted in the shaft and it carries out diameter expansion (expansion) association, it receives an impact load, the input attaches it, and it causes a crack of the cam piece 1 at the time. In this case, it acts advantageously that the internal hardness of the cam piece 1 is low as mentioned above, and it becomes possible for shock resistance to improve and to prevent generating of the crack of the cam piece 1 at the time of diameter expansion. If the ingredient which raised impact strength by adding boron (B) beforehand as Material W or Wc especially is used, it will become more advantageous on the crack prevention at the time of the above-mentioned diameter expansion processing.

[0059] The drawing below drawing 10 shows the concrete processing procedure of the multi-process forging press machine under the above-mentioned manufacture approach.

[0060] Drawing 10 shows the primary forming cycle of the above-mentioned contour-forming processes, and after inserting the material Wc of a variant configuration as shown at drawing 11 in the dice 22 which has knock out pin 21, it sets it by punch 23. In the middle of Material Wc, by this the process configuration W1, i.e., a middle Plastic solid It becomes a configuration with a level difference so that the direction of field 5a by the side of the cam crowning 3 may become high, though field 5a, it, and field 5b of the opposite side which are equivalent to the cam crowning 3 side among the fields equivalent to one side face of the cam piece 1 which is a product are parallel to the side face of another side as shown also in drawing 12 . Forging shaping is carried out at the configuration which the thickness dimension as middle Plastic

solid W1 increases gradually toward the cam crowning 3 side as a result.

[0061] Drawing 13 shows the secondary-forming process of the contour-forming processes, after inserting middle Plastic solid W1 shown in drawing 12 into the dice 25 which has a lower punch 24, it sets it by the upper punch 26, and it carries out printing pressure shaping of the cavities 4a and 4b to both sides while carrying out flattening so that a level difference, two comrades (field 5a and 5b), may be lost. Middle Plastic solid W1 as shown in drawing 14 by this is acquired. In addition, since Cavities 4a and 4b function as a prepared hole of the shaft hole 2 like the hole spline configuration described previously, in order to bring close to the configuration, they have been made into the polygonal configuration here.

[0062] Drawing 15 carries out pressurization constraint of middle Plastic solid W1 which shows the correction process following a contour-forming process, and was shown in drawing 14 by the lower punch 28 and the upper punch 29 within the dice 27, and corrects a configuration. Middle Plastic solid W1 with which configuration precision was raised more as the result as shown in drawing 16 is acquired.

[0063] Drawing 17 shows the pierced earring process, and pierces and fabricates the shaft hole 2 to middle Plastic solid W1 shown in drawing 16 based on shearing of a piercing punch 33 and an upper punch 32 within a dice 30. In addition, the tip of a piercing punch 33 is formed in the axial spline configuration, and Scrap S is generated by the center section of middle Plastic solid W1 being pierced as a shaft hole 2, as shown in drawing 18.

[0064] To middle Plastic solid W1 which shows the bore ironing process and was shown in drawing 18 within the dice 34, drawing 19 presses the counterpunch 37 of the axial spline configuration for bore ironing fit in the shaft hole 2, and finishes the shaft hole 2 in the shape of [of a hole spline configuration] normal form. As the result, the cam piece 1 as shown in drawing 20 will be obtained. In addition, the counterpunch 47 which replaced with the counterpunch 37 shown in drawing 19, and was shown in drawing 21 can also be used.

[0065] The drawing below drawing 22 shows the example when the so-called multistage type cold-forging machine (cold former) of a horizontal **** type is made to perform shaping at each process which is drawing showing the gestalt of operation of the 2nd of this invention, and was shown in (B) of drawing 1, and (C).

[0066] The multistage type cold-forging machine 50 has the primary forming cycle S2 of a contour-forming process and the secondary-forming process S3, and correction process S4, the pierced earring process S5, the bore cover-printing process S6 and the work-piece discharge process S7 as well as the cutting process S1 which cuts the

material Wc of a variant configuration as shown in drawing 2 from a coil strip by making a bolster 51 into a subject, as shown in drawing 22 besides drawing 1 . In addition, it is considered beforehand that it combines with the completeness as cam piece 1 increasing, and the outer-diameter dimension becomes large gradually, passing through some processes of (B) of drawing 1 , and (C).

[0067] While the space of drawing 22 , the cutter 52 which cuts the coil strip (it mentions later about the coil strip itself) supplied from a rectangular cross for the material Wc of a variant configuration like drawing 2 , and the gripper 53 which grasps the material Wc after cutting are formed in the cutting process S1, the dice 54 is formed in the primary forming cycle S2, the secondary-forming process S3, correction process S4, the pierced earring process S5, and the bore cover-printing process S6 at each. Moreover, the work-piece discharge punch 55 which appears frequently from the space and the rectangular direction of drawing 22 is formed in the last work-piece discharge process S7. and -- since this multistage type cold-forging machine 50 can be understood to be what leveled drawing 10 and the direction of an opposite axis of the dice and punch in 13, 15, 17, and 19 -- a bolster 51 -- receiving -- the approach from a horizontal direction -- alienation -- the punch which counters each dice is formed in the ram besides the illustration which operates.

[0068] The transport device 56 for carrying out sequential conveyance of middle Plastic solid W1 fabricated at each processes S2-S6 at degree process is formed above the bolster 51. This transport device 56 an air cylinder or a servo motor to the slider 58 which carries out level round trip migration based on the actuation of the drive unit 57 made into a subject It is a thing equipped with a total of five grippers 59A-59E for grasping middle Plastic solid W1 or the cam piece 1. While each grippers 59A-59E are located so that it may not interfere in the front-face side of the corresponding dice 54 with this, the reciprocation stroke of a slider 58 and spacing of grippers are set up so that it may become equal to each process S2 - the pitch between S7. In addition, the multistage type forging machine equipped with this kind of transport device is well-known at JP,11-47877,A etc.

[0069] And if the condition of drawing 22 is made into a conveyance standby condition, middle Plastic solid W1 which finished shaping at each processes S2-S6 will be grasped by each grippers 59A-59E which are in a conveyance standby condition so that it may mention later. Middle Plastic solid W1 currently grasped by each grippers 59A-59E because each grippers 59A-59E move to degree process all at once based on the forward movement of a slider 58 after that is conveyed to degree process. Each grippers 59A-59E will return to the location again shown in a conveyance

standby condition, i.e., drawing 22 , based on double-acting actuation of a slider 58, after standing by at degree process with a slider 58 temporarily and completing shaping until shaping at degree the process is completed.

[0070] In addition, the duty which conveys this to the primary forming cycle S2 after grasping the material Wc of the variant configuration cut from the coil strip by the cutter 52 of the cutting process S1 so that the gripper 53 in the cutting process S1 may also carry out synchronous actuation with each above-mentioned grippers 59A-59E and may mention later is carried out.

[0071] Each gripper 53, and 59A-59E are equipped with the piece 60 of a pawl of the pair in which rocking closing motion is free as shown in drawing 23, and they grasp middle Plastic solid W1 or the cam piece 1 to each piece 60 of a pawl by the retention span determined with the spring constant of flat spring 62 by connecting the gripper body 61 and each piece 60 of a pawl by flat spring 62. When the punch only with the bigger specified quantity than middle Plastic solid W1 which the piece 60 of a pawl is grasping has advanced into the opening edge of the grasping side in each piece 60 of a pawl so that comparatively big C beveling (a sign 63 shows a chamfer) may be performed and it may mention later, it permits extruding middle Plastic solid W1, extending the piece 60 of a pawl with the punch.

[0072] Here, in connection with sequential processing progressing to the bore cover-printing process S6 from the primary forming cycle S2, it is beforehand set up so that the profile configuration as middle Plastic solid W1 may become little by little large each time, therefore each grippers 59A-59E have given beforehand the grasping cost which can respond to the difference in the above-mentioned profile configuration.

[0073] Therefore, if the detail is explained according to the structure of such a multistage type cold-forging machine 50, referring to drawing 24 , for example by making the primary forming cycle S2 into the example of representation, as shown in this drawing (A) Synchronizing with the forward movement of the previous slider 58, the material W of the variant configuration after cutting processing is conveyed to the front location of the dice 54 of the primary forming cycle S2, after having been grasped by the gripper 553, and it is positioned in the location. That is, a dice 54 side carves (impression), and it is positioned so that 64 and the profile of the material W currently grasped by the gripper 53 may be in agreement. And if punch 65 of the primary forming cycle S2 carries out advance actuation, Material W will be pushed in in the carve lump 64, and while punch 65 extends the piece 60 of a pawl of a gripper 53, as shown in this drawing (B), primary shaping will be given with the same gestalt as drawing 10 .

[0074] After primary shaping is completed, as shown in this drawing (C), punch 65 retreats first, and all the grippers 59A–59E (Grippers 59A–59E all are not grasping Material Wc or middle Plastic solid W1) containing the gripper 53 which was subsequently standing by by the primary forming cycle S2 till then return to the original location all at once by double-acting actuation of a slider 58. By this, gripper 59A will be located in the primary forming cycle S2 instead of a gripper 53. while a knockout punch (knock out pin) 66 carries out advance actuation as shown in this drawing (D) in this condition, and extruding middle Plastic solid W1 in the carve lump 64 -- in addition -- and the piece 60 of a pawl of gripper 59A is extended with that middle Plastic solid W1, and gripper 59A is made to grasp middle Plastic solid W1 after primary shaping Shortly after gripper 59A grasps middle Plastic solid W1, a knockout punch 66 returns to the original location.

[0075] When this condition is the same as the condition of this drawing (A) except that gripper 59A was changed, therefore the slider 58 of a transport device 56 performs the next conveyance actuation, middle Plastic solid W1 after the primary shaping termination currently grasped by that gripper 59A will be conveyed to the following secondary-forming process S3.

[0076] Such a series of actuation is fundamentally the same also in each processes S3–S6 other than primary forming cycle S2, and actuation of all the processes S1–S7 synchronizes, and it is performed in parallel. However, in the work-piece discharge process S7, as shown in drawing 25 , synchronizing with the knockout punch 66 of each processes S2–S6 carrying out advance actuation, work-piece discharge punch 67 carries out advance actuation, and only actuation which extrudes the cam piece 1 (refer to drawing 1) which finished bore ironing from gripper 59E is performed. And the cam piece released from gripper 58E is collected as a product.

[0077] The carve lump 64 of the dice 54 in each processes S2–S6 here It is set up so that the so-called cam top equivalent section which will manage shaping of the cam crowning 3 as shown in drawing 26 may serve as facing down. The conveyance posture of the material Wc by the gripper 53 and transport device 56 which were described previously, or middle Plastic solid W1 is also beforehand set up for that cam crowning 3 side so that it may become facing down, in order to double the posture of middle Plastic solid W1 with coincidence to the posture of this lump [carve] 64.

[0078] Therefore, if it explains taking the case of the primary forming cycle S2 shown in drawing 24 In case this is stuffed into the carve lump 64, releasing the material Wc of a variant configuration from a gripper 53 by extrusion actuation by punch 65 Only few amounts beta carry out self-weight fall of the material Wc at the moment of being

released from a gripper 53, as shown also in drawing 26 and 27. Since the cam crowning 3 side is downward, Material Wc and the cam top equivalent section of the lump [carve] 64 will agree immediately with the profile by the side of the cam crowning 3, and the so-called self ROKETO function or an automatic alignment function will be demonstrated.

[0079] In more detail, as shown also in drawing 27 , only the specified quantity beta carries out self-weight fall at the moment of the material Wc of the variant configuration currently grasped by the gripper 53 having been extruded by punch 65, and being released from the retention span. Primary shaping will be given by the cam crowning 3 and cam top equivalent section by the side of the carve lump 64 agreeing immediately, and being pushed into the pars-basilaris-ossis-occipitalis side of the lump [carve] 64 while it has been in the condition in which ingredient allocation inclined toward the cam crowning 3 side substantially.

[0080] Therefore, ingredient allocation inclines toward the cam crowning 3 side from the quite early stage rather than the welding pressure of punch 65 acts on Material Wc. Would give priority to the cam crowning 3 side beforehand, and the ingredient (material meat) will be full. The cam crowning 3 side it is supposed that an ingredient cannot be easily full of the crowning harder [which is acute /-like / with last thing] in many cases can be made fully filled with an ingredient, especially, generating of the thickness deviation by the side of the cam crowning 3 or under-fill is prevented, and it can also be contributed to the forging progression in quality now that it is cold forging.

[0081] conversely, when saying and the sense of the lump [carve] 64 in each dice 54 is set up so that the cam crowning 3 side may serve as facing up as shown in drawing 28 The moment Material Wc carried out self-weight fall, Material Wc falls over within the carve lump 64, a phenomenon occurs, especially since ingredient fullness is insufficient, it becomes easy to generate the thickness deviation and under-fill by the side of the cam crowning 3, and such fault can be effectively canceled with the gestalt of the above-mentioned implementation.

[0082] In addition, although drawing 26 and the behavior of 27 were explained taking the case of drawing 1 and the primary forming cycle S2 shown in 24, the behavior is fundamentally the same also about each other processes S3-S6. Moreover, even when W is used for the material W of the shape of a cylinder as replaced with the material Wc of a variant configuration and shown in drawing 1 , it cannot be overemphasized that the ingredient allocation which thought the cam crowning 3 side as important similarly so that clearly from drawing 29 can be given.

[0083] Furthermore, when it sees about the relation between the carve lump 64 of the

dice 54 in the primary forming cycle S2 described previously, and the carve lump 64 of the secondary-forming process S3 which is a back process as shown in drawing 30 for example, Since it is premised on carrying out the parallel displacement of middle Plastic solid W1 horizontally [process / S3 / which is a back process / secondary-forming], and conveying it from the primary forming cycle S2 which is a last process, The center-of-gravity location G of the lump [carve] 64 of both sides is made mutually in agreement, and as shown in drawing 26 and 27, in case it stuffs middle Plastic solid W1 into the carve lump 64 of the secondary-forming process S3 accumulating, middle Plastic solid W1 will carry out self-weight fall only of the specified quantity beta.

[0084] Then, when only the specified quantity a (=beta) makes the center-of-gravity location G of the lump [carve] 64 of the secondary-forming process S3 which is a back process offset beforehand up to the center-of-gravity location G of the lump [carve] 64 of the primary forming cycle S2 which is a last process as shown in drawing 30 , the above-mentioned self-weight deposit beta will be offset. That is, the height location of the section [cam crowning 3 and cam top equivalent section by the side of the carve lump 64] will already have corresponded in the phase where middle Plastic solid W1 conveyed from the primary forming cycle S2 as shown in drawing 32 is grasped by gripper 59A. Without being accompanied by the previous self-weight fall only for the amount beta of offset, as an interrelation of the carve lump 64 and middle Plastic solid W1, ingredient allocation can be made into priority or the condition of having made it inclining at the cam crowning 3 side, and the relative-position arrangement precision of middle Plastic solid W1 and the lump [carve] 64 improves much more.

[0085] As shown in drawing 30 , even if it is the case where the above amounts a of offset are not set up between the carve lump 64 by the primary forming cycle S2 which is a last process, and the secondary-forming process S3 which is a back process, and 64 comrades here If it sets up so that the cam crowning 3 side may serve as facing down as a conveyance posture of middle Plastic solid W1 If it is made to drop middle Plastic solid W1 positively by the above-mentioned amount a of offset, and the EQC in the conveyance process of middle Plastic solid W1 from the primary forming cycle S2 to the secondary-forming process S3 (offset), the same effectiveness as the above will be acquired.

[0086] A setup of the amount a of offset of the lump [carve] 64 between these before process and a back process (=beta) or the amount a of offset in a conveyance process is similarly set up in other process S4-S6 by which two processes will adjoin

mutually.

[0087] Next, the desirable gestalt of the coil strip of the variant configuration which will be supplied to the multistage type cold-forging machine 50 of drawing 22 is explained.

[0088] The cylindrical material Wn fabricated by the continuous casting process, for example as shown in drawing 3 is made into a coil strip 70 by being rolled round by the predetermined drum by making the field of the opposite side into the inside with the cam crowning 3 side at a back process, as shown in drawing 33, and this coil strip 70 is set to the uncoiler 71 arranged at the preceding paragraph of the multistage type cold-forging machine 50 as shown in drawing 34. In addition, when the cam crowning 3 side is carried out inside, since the touch area is small, carrying out the cam crowning 3 side outside, and rolling round the cylindrical material Wn, as shown in drawing 33 has bad stability, and it is because there is a possibility of making the most important cam crowning 3 deforming on a function. And a coil strip 70 will be supplied to the multistage type cold-forging machine 50, after passing through a straightening machine 72, being rewound by the uncoiler 71, and it will be sent out one by one from the dice of the cutting process S1 of drawing 22.

[0089] In this case, if it sets to an uncoiler 71 so that the rewinding starting position 73 of a coil strip 70 may turn up as shown in drawing 34, in the leader of a coil strip 70, it will not be in agreement with the posture in which the cam crowning 3 side becomes facing up, and the posture 3, i.e., cam crowning, side made into an ideal becomes the multistage type forging which was described previously with facing down. Therefore, by the time it conveys the material Wn cut at the cutting process S1 to the primary forming cycle S2, it will be necessary to make the posture reversed, and it is not desirable.

[0090] Then, it can be made now in agreement with the posture in which the posture [in which the posture in the leader of a coil strip 70 is made into an ideal at multistage type forging] 3, i.e., cam crowning, side serves as facing down, by setting the coil strip 70 to an uncoiler 71, and carrying out it like this so that the rewinding starting position 73 of a coil strip 70 may turn up, as shown in drawing 35.

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1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The explanatory view showing the outline configuration of the process as a gestalt of desirable implementation of the manufacture approach of the cam piece concerning this invention.

[Drawing 2] The explanatory view which compared the material and product configuration of a variant configuration.

[Drawing 3] The explanatory view showing the outline of the continuous casting process for obtaining a cylindrical material.

[Drawing 4] The configuration explanatory view of the middle Plastic solid which carried out owner stage shaping.

[Drawing 5] The explanatory view which compared with the product configuration the middle Plastic solid which is a process configuration the middle.

[Drawing 6] The explanatory view of a secondary-forming process using drawing 4 and the middle Plastic solid of 5.

[Drawing 7] The explanatory view of a secondary-forming process in case two parallel fields cannot be mutually found in a middle Plastic solid.

[Drawing 8] The explanatory view of the cam piece completed with the bore cover-printing process of drawing 1 .

[Drawing 9] The property Fig. showing hardness distribution of the cam piece after carburization hardening processing.

[Drawing 10] The important section expansion explanatory view showing the detail of a primary forming cycle among the contour-forming processes shown in drawing 1 .

[Drawing 11] The explanatory view of the material of the variant configuration used by the primary forming cycle of drawing 10 .

[Drawing 12] The explanatory view of the middle Plastic solid acquired by the primary forming cycle of drawing 10 .

[Drawing 13] The important section expansion explanatory view showing the detail of a secondary-forming process among the contour-forming processes shown in drawing 1 .

[Drawing 14] The explanatory view of the middle Plastic solid acquired at the secondary-forming process of drawing 13 .

[Drawing 15] The important section expansion explanatory view showing the detail of the correction process shown in drawing 1 .

[Drawing 16] The explanatory view of the middle Plastic solid acquired at the correction process of drawing 15 .

[Drawing 17] The important section expansion explanatory view showing the detail of the pierced earring process shown in drawing 1 .

[Drawing 18] The explanatory view of the middle Plastic solid acquired at the pierced earring process of drawing 17 .

[Drawing 19] The important section expansion explanatory view showing the detail of the bore cover-printing process shown in drawing 1 .

[Drawing 20] The explanatory view of the cam piece completed with the bore cover-printing process of drawing 19 .

[Drawing 21] The explanatory view showing other examples of the tool used at the bore cover-printing process of drawing 19 .

[Drawing 22] The transverse-plane explanatory view showing the outline configuration of the multistage type cold-forging machine of a horizontal **** type as a gestalt of operation of the 2nd of this invention.

[Drawing 23] The important section enlarged drawing of the gripper used with the multistage type cold-forging machine of drawing 22 .

[Drawing 24] The cross-section explanatory view showing the material between the dices and grippers in the primary forming cycle of drawing 22 , or the delivery condition of a middle Plastic solid.

[Drawing 25] The cross-section explanatory view showing actuation at the work-piece discharge process of drawing 22 .

[Drawing 26] The explanatory view showing the relation between the material in a primary forming cycle, and the carve lump by the side of a dice.

[Drawing 27] The actuation explanatory view in the vertical section of drawing 26 .

[Drawing 28] The explanatory view at the time of making the material of drawing 26 , and the sense of a lump [carve] into the reverse sense.

[Drawing 29] The explanatory view showing the relation between the material at the time of replacing with the material of the variant configuration of drawing 26 , and

using a cylindrical material, and the carve lump by the side of a dice.

[Drawing 30] The explanatory view showing the relative-position relation of a lump [carve] of a primary forming cycle and a secondary-forming process to drawing 22 .

[Drawing 31] The explanatory view at the time of drawing 30 carving and setting up the amount of offset of the specified quantity in the vertical direction as relative-position relation of lumps.

[Drawing 32] The actuation explanatory view in the vertical section of drawing 31 .

[Drawing 33] The important section enlarged section explanatory view of the coil strip before being cut as a material of a variant configuration.

[Drawing 34] The explanatory view showing the general set condition of the coil strip to an uncoiler.

[Drawing 35] The explanatory view showing the set condition over the uncoiler of the coil strip adopted with the gestalt of the 2nd operation.

[Description of Notations]

1 -- Cam piece as a product

2 -- Shaft hole

3 -- Cam crowning (nose section)

4 -- Cavity

4a, 4b -- Cavity

5a, 5b -- Flat surface

50 -- Multistage type cold-forging machine of a horizontal **** type

64 -- Carve lump

70 -- Coil strip

71 -- Uncoiler

73 -- Rewinding starting position

Q -- Under-fill

R0 -- Curvature of the cam crowning as the circular section

S1 -- Cutting process

S2 -- Primary forming cycle (contour-forming process)

S3 -- Secondary-forming process (contour-forming process)

S4 -- Correction process

S5 -- Pierced earring process

S6 -- Bore cover-printing process

S7 -- Work-piece discharge process

W -- Material

W1 -- Middle Plastic solid

Wc -- Material of a variant configuration

[Translation done.]

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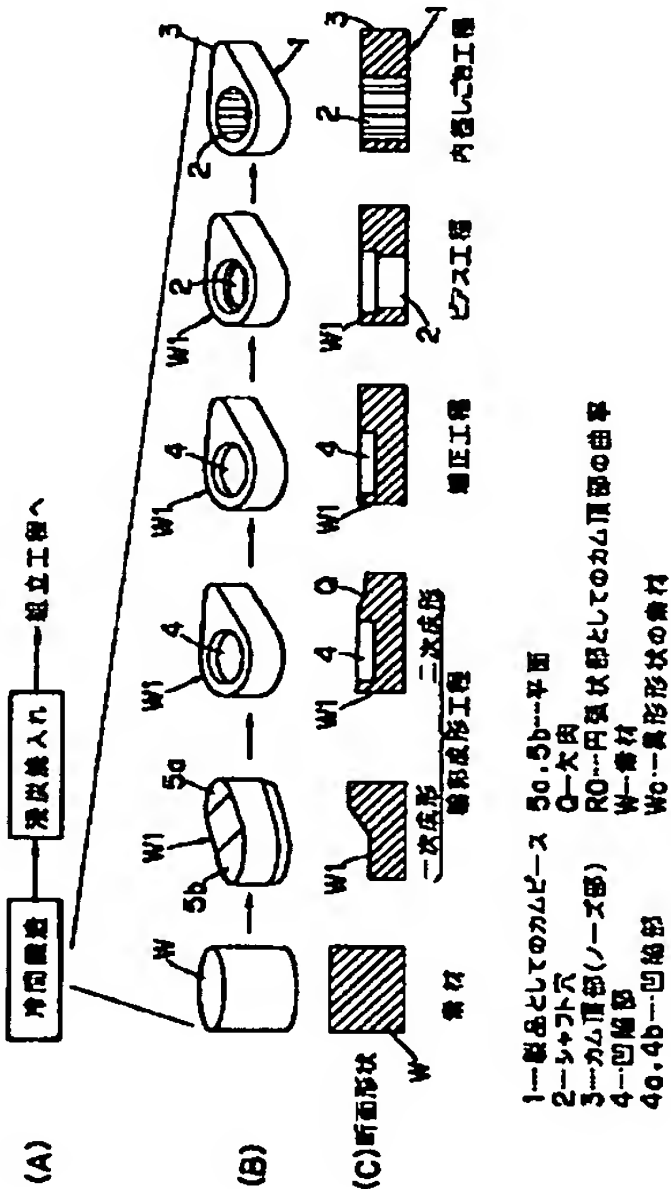
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(54)【発明の名称】 組立式カムシャフト用カムピースの製造方法

(57)【要約】

【課題】 冷間鍛造を基本とした形状精度の優れたカムピースの製造方法を提供する。

【解決手段】 素材Wを据え込んでカムピース1の輪郭形状を鍛造成形する輪郭成形工程と、中間成形体W1の中央部にシャフト穴2を打ち抜き成形するピアス工程と、シャフト穴2の内周面を仕上げる内径しごき工程とを含んでいて、各工程での成形が冷間処理として行われる。輪郭成形工程の一次成形で得られる中間成形体W1は、カムピース1の一方の側面に相当する面のうちカム頂部3側の面5aとそれと反対側の面5bとが他方の側面と平行でありながらカム頂部3側の面5aの方が高くなるように段差を有した形状となっていて、中間成形体W1としての厚み寸法がカム頂部3側に向かって漸増する形状となっている。



【特許請求の範囲】

【請求項1】 素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、

上記輪郭成形工程での素材の途中工程形状として、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、素材としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする組立式カムシャフト用カムピースの製造方法。

【請求項2】 上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とに分かれていて、一次成形後の中間成形体は、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、中間成形体としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする請求項1に記載の組立式カムシャフト用カムピースの製造方法。

【請求項3】 素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、

上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることを特徴とする組立式カムシャフト用カムピースの製造方法。

【請求項4】 上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることを特徴とする請求項3に記載の組立式カムシャフト用カムピースの製造方法。

【請求項5】 上記輪郭成形工程に投入される素材はカムピースと相似形をなして、その素材の長径と短径との比率がカムピースと同じ比率に設定されていることを特徴とする請求項4に記載の組立式カムシャフト用カムピースの製造方法。

【請求項6】 上記輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法を基本工法とする請求項1～5のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【請求項7】 上記素材は低炭素鋼もしくは低炭素の合金鋼であり、輪郭成形工程とピアス工程および内径しごき工程とを含んでなる冷間処理後に浸炭処理を施すことを特徴とする請求項1～6のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

10 【請求項8】 素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、

少なくとも上記各工程での成形が、カム頂部側を下向きにした状態でそれぞれ冷間処理として横打ち式の多段式鍛造機にて行われるようになっていることを特徴とする組立式カムシャフト用カムピースの製造方法。

20 【請求項9】 上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とが含まれていることを特徴とする請求項8に記載の組立式カムシャフト用カムピースの製造方法。

【請求項10】 上記各工程での成形とともに、各工程間での中間成形体の搬送が同じくカム頂部側を下向きにした状態で行われるようになっていることを特徴とする請求項8または9に記載の組立式カムシャフト用カムピースの製造方法。

30 【請求項11】 隣り合う二つの工程のうち前工程で成形された中間成形体の輪郭形状よりも後工程で成形された中間成形体の輪郭形状の方が大きくなるように設定されていて、

後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入することを特徴とする請求項8～10のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

40 【請求項12】 予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、

前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせてあることを特徴とする請求項11に記載の組立式カムシャフト用カムピースの製造方法。

【請求項13】 予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、

50 前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させることを特徴とする請求項11に記載の組立式カムシャフト用

カムピースの製造方法。

【請求項14】 カムピースの形状と略相似形の断面形状をもつ異形状で且つ長尺なコイル材を多段式鍛造機の初期工程に供給して、コイル材からの素材の切断までも多段式鍛造機にて行うようにした組立式カムシャフト用カムピースの製造方法であって、カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が下側になるようにそのコイル材をアンコイラーにセットして、そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを特徴とする請求項8～13のいずれかに記載の組立式カムシャフト用カムピースの製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、内燃機関の動弁系の主要素として機能することになる組立式カムシャフト用カムピースの製造方法に関し、特に別々に形成した中空状シャフトと鍛造品であるカムピースとをシャフトの拡張（拡張）処理により相互に一体化して組立式カムシャフトとするのに好適なカムピースの製造方法に関する。

【0002】

【従来の技術と発明が解決しようとする課題】組立式カムシャフトのカムピース（カムロブ（cam lobe）もしくはカムロップとも称される）としては焼結品のほか鍛造品が用いられており、鍛造品のカムピースの場合には特に表面硬さを確保するために素材として例えばS70C、S55C相当の高炭素鋼を用い、鍛造後に焼入れ処理を施した上で使用される。そして、鍛造品のカムピースは、例えば特開平9-276976号公報および特開平9-280013号公報に示されているように成形性に優れた熱間鍛造により成形されるのが一般的である。

【0003】一方、組立式カムシャフトはカムピースとパイプ状のシャフトとの圧入強度および相互組み付け精度を両者の圧入代で保証するようにしているため、シャフトの外形寸法およびカムピースの内径寸法には高い精度が要求されることになるが、熱間鍛造にて成形された高炭素鋼の鍛造カムピースの場合には熱間鍛造時の酸化スケールの発生や熱収縮による寸法変化のために部品としての要求精度を十分に確保することができない。そのため、カムピースの内径寸法確保のためにブローチ加工に代表されるような切削加工もしくは冷間塑性加工等の仕上げ加工を別工程にて施す必要があり、工程数の増加および中間在庫の管理工数の増加によるコストアップが余儀なくされる。

【0004】また、高炭素鋼の鍛造カムピースの場合、表面硬さを確保するために焼入れ処理を施す必要があるが、材質自体の特殊性として焼入れ時における焼き割れを皆無にすることは不可能であり、その焼き割れを原因

とする圧入組立時の破損や圧入力不足の発生を未然に防止するために焼き割れ発生の有無の検査や焼き割れ品の選別工程が必須となり、歩留まりの低下とともに工程数の増加によるコストアップが一層顕著となる。

【0005】そこで、熱間鍛造に代わる冷間鍛造を基本としたカムピースの製造方法が特許第2767323号公報として提案されている。

【0006】ところが、冷間鍛造は熱間鍛造に比べて鍛造成形性（素材内の流動性）が低いために、欠肉等の欠陥が発生しやすいばかりでなく、素材から必要な製品形状まで塑性変形させる際に変形量を十分に小さくしないと型に対する成形荷重が大きくなり、型の摩耗が激しくなって型の早期寿命を招きやすい。

【0007】特に、中実円筒状の素材を軸方向に据え込んで圧縮した場合には外周方向にほぼ均等な量だけ膨出するかたちとなるので、単純な円形状もしくはそれに近い形状に成形することは比較的容易ではあっても、円形のベースサークルとこれよりも著しく曲率半径の小さなカム頂部となるべき円弧部（ノーズ部）とを合成したようなカムピース形状に一気に且つ欠肉の発生のないように成形することは難しい。そのため、素材から製品形状まで微少量づつ塑性変形させて成形するべく加工工程数を多くする必要があり、鍛造設備が大型且つ高価なものとなるばかりでなく、加工時間も長くなって生産性の低下を招きやすい。

【0008】本発明はこのような課題に着目してなされたものであり、冷間鍛造を前提としながらもより少ない工程数でしかも欠肉等の発生のない高精度なカムピースを製造できるようにした方法を提供するものである。

【0009】

【課題を解決するための手段】請求項1に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、上記輪郭成形工程での素材の途中工程形状として、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行でありながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、素材としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする。

【0010】また、請求項2に記載の発明は、請求項1の記載をより具体化したものであり、上記輪郭成形工程は少なくとも一次成形工程とそれに続く二次成形工程とに分かれている。そして、一次成形後の中間成形体は、カムピースの一方の側面に相当する面のうちカム頂部側の部分とそれと反対側の部分とが他方の側面と平行であ

りながらカム頂部側の部分の方が高くなるように段差を有した形状となっていることにより、中間成形体としての厚み寸法がカム頂部側に向かって漸増する形状となっていることを特徴とする。

【0011】この場合、素材としては例えば円柱状（中実円筒状）のものでもよいが、材料の塑性流動を一段と促進して欠肉等の欠陥を防止する上では、最終製品であるカムピースの形状と相似形の素材を用いることが望ましい。

【0012】したがって、この請求項1、2に記載の発明では、大きく分けて輪郭成形工程とピアス工程および内径しごき工程を経ることによりシャフト穴を有するカムピースが成形されることになるが、輪郭成形工程における素材の途中工程形状であるところの一次成形後の中間成形体として、カム頂部側に向かって肉厚寸法が漸増する形状となっていると、その後の鍛造成形もしくは一次成形に続く二次成形の段階でカムピースの長径方向での肉流れすなわち塑性流動が促進されるようになり、特にカム頂部側での欠肉発生防止の上で有効に作用するようになる。

【0013】請求項3に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、上記各工程での成形が冷間処理として行われるとともに、上記輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることを特徴とする。

【0014】したがって、この請求項3に記載の発明では、上記と同様に少なくとも輪郭成形工程とピアス工程および内径しごき工程を経ることによりシャフト穴を有するカムピースが成形されることになるが、素材のうち少なくともカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていると、冷間鍛造によるカムピースの輪郭の成形、特に長径と短径との差の大きなカムピースを成形する上で有利となる。

【0015】請求項4に記載の発明は、請求項3の記載を前提として、輪郭成形工程に投入される素材には、少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることを特徴とする。

【0016】ここで、上記開き角とは、カムピースのベースサークルとこれよりも小さなカム頂部の円弧部とを両者が共有する二つの接線にてつなげた形状の接線カムを想定した場合に二つの接線同士のなす角度をいう。

【0017】この場合、請求項5に記載のように、輪郭成形工程に投入される素材はカムピースと相似形をなし

ていて、その素材の長径と短径との比率がカムピースと同じ比率に設定されていることが望ましい。

【0018】したがって、これらの請求項4、5に記載の発明では、素材のうち少なくともカム頂部に相当する部分もしくは素材全体が予め最終製品であるカムピースの形状と相似形に形成されていることにほかならず、冷間鍛造によるカムピースの輪郭の成形の一段と容易となる。

【0019】ここで、上記請求項1～5に記載の発明においては、請求項6に記載のように、いずれの場合にも輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法すなわち多段式冷間鍛造機による工法を基本工法とすることが生産性向上の上で好ましい。

【0020】また、請求項7に記載のように、請求項1～6のいずれかの記載を前提とした上で、素材として低炭素鋼もしくは低炭素の合金鋼を用い、輪郭成形工程とピアス工程および内径しごき工程とを含んでなる冷間処理後に浸炭処理を施すことが冷間での成形性向上の上で望ましい。

【0021】請求項8に記載の発明は、素材をカムピースの厚み方向に据え込んでカムピースの輪郭形状を鍛造成形する輪郭成形工程と、輪郭成形後の中間成形体の中央部にシャフト穴を打ち抜き成形するピアス工程と、シャフト穴の内周面を凹凸形状に仕上げ成形する内径しごき工程とを含んでいて、少なくとも上記各工程での成形が、カム頂部側を下向きにした状態でそれぞれ冷間処理として横打ち式の多段式鍛造機にて行われるようになっていることを特徴とする。

【0022】この場合、請求項9に記載のように、上記輪郭成形工程には少なくとも一次成形工程とそれに続く二次成形工程とが含まれていてもよい。

【0023】また、請求項10に記載のように、各工程での成形とともに、各工程間での中間成形体の搬送が同じくカム頂部側を下向きにした状態で行われるようになっていることがより望ましい。

【0024】したがって、これらの請求項8～10に記載の発明では、中間成形体を前工程から後工程に搬送してその後工程側の金型（ダイス）の彫り込み（インプレッション（impression）ともいう）に挿入すれば、中間成形体のカム頂部とその成形を司る彫り込みのカム頂部相当部とがセルフロケート機能もしくは自動調芯機能を発揮し、早い時期から両者が合致して、彫り込み内での中間成形体のいわゆる転がり現象が防止されることになる。これは、彫り込みに対して中間成形体の位置がカム頂部側に偏っていて、材料（素材肉）ボリュームの配分がそのカム頂部側に偏っていることにほかならないから、カム頂部側へ優先して材料ボリュームが配分されてそのカム頂部側での材料充満が促進され、機能上最も重要なカム頂部側での偏肉や欠肉を防止する上で

きわめて有効に作用するようになる。

【0025】請求項11に記載の発明は、請求項8～10のいずれかの記載の前提として、隣り合う二つの工程のうち前工程で成形された中間成形体の輪郭形状よりも後工程で成形された中間成形体の輪郭形状の方が大きくなるように設定されていて、後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入することを特徴とする。

【0026】より具体的には、請求項12に記載のように、予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせておくか、もしくは請求項13に記載のように、予めカム頂部を後工程側の彫り込みのカム頂部相当部に合致させた上で中間成形体を押し込み挿入する手段として、前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させるものとする。

【0027】したがって、これら請求項11～13に記載の発明では、後工程の彫り込みに対して前工程からの中間成形体を挿入する際に、その中間成形体のカム頂部と彫り込み側のカム頂部相当部が自律的に合致するようになる。

【0028】請求項14に記載の発明は、請求項8～13のいずれかの記載を前提とした上で、カムピースの形状と略相似形の断面形状をもつ異形状で且つ長尺なコイル材を多段式鍛造機の初期工程に供給して、コイル材からの素材の切断までも多段式鍛造機にて行うにあたり、カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が下側になるようにそのコイル材をアンコイラーにセットして、そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを特徴とする。

【0029】すなわち、カム頂部相当部を外側にして巻き取ったコイル材の巻き戻し開始位置が上側になるようにコイル材をアンコイラーにセットして、そのコイル材を巻き戻しながら上記多段式鍛造機に供給することを前提とした場合、そのコイル材から切断された素材の向きはカム頂部側が上向きとなり、先に述べたようなカム頂部側が下向きとなるような理想的な姿勢とは逆の姿勢とならざるを得ないことから、請求項14に記載の発明ではコイル材の巻き戻し開始位置が下側になるように予め考慮したものである。

【0030】したがって、この請求項14に記載の発明では、多段式鍛造機に切断材ではなくコイル材を直接供給して、素材そのものの切断までも多段式鍛造機にて行うことを前提とした場合に、切断直後の素材の向きが各工程での成形姿勢と一致したものとなり、鍛造工程の高速化の上でより好ましいものとなる。

【0031】

【発明の効果】請求項1、2に記載の発明によれば、少なくとも輪郭成形工程とピアス工程および内径しごき工程とを含んでなる製造方法を前提として、輪郭成形工程における素材の途中工程形状であるところの一次成形後の中間成形体の形状として、カム頂部側に向かって肉厚寸法が漸増する形状となっていることから、カムピースの長径方向の肉流れが促進されるとともに、カム頂部側での素材肉の流速が相対的に大きくなってそのカム頂部側に速やかに充満することから、曲率半径の小さなカム頂部を速やかに且つ欠肉等の発生を伴うことなく容易に成形できる効果がある。また、カム頂部側まで素材肉を充満させるのに必要な成形荷重が軽減されて、金型の負荷の低減と併せてその長寿命化を達成できるようになる。

【0032】請求項3に記載の発明によれば、輪郭成形工程に投入される素材には少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の曲率の円弧状部が予め形成されていることにより、特に長径と短径との差の大きなカムピースすなわちカムリフト量の大きなカムピースを冷間鍛造成形する際の輪郭形状の成形が容易となり、特に曲率半径の小さなカム頂部までも少ない工程数で容易に成形できる効果があるほか、上記と同様に金型の負荷の低減と併せてその長寿命化を達成できる利点もある。

【0033】請求項4に記載の発明によれば、輪郭成形工程に投入される素材には少なくともカムピースのカム頂部となるべき部分にそのカムピースの頂部と同等の開き角が予め付与されていることにより、請求項3に記載の発明と同様の効果に加えて、カムピースの輪郭形状の成形が一層容易となり、さらなる工程数の削減と金型の長寿命化を達成できるようになるほか、特に請求項5に記載のように、素材がカムピースと相似形をなしてその素材の長径と短径との比率がカムピースと同じ比率に設定されていると上記の効果が一段と顕著となる。

【0034】請求項6に記載の発明によれば、請求項1～5のいずれの記載においても輪郭成形工程とピアス工程および内径しごき工程を含んでなる多工程鍛造プレス工法を基本工法としているため、必要最小限の工程数で所期の目的を達成することができるとともに連続成形が可能となり、工程数の削減と中間在庫の解消によるコストダウンならびに生産性の向上を図ることが可能となる。

【0035】請求項7に記載の発明によれば、素材として冷間での成形性に優れた低炭素鋼もしくは低炭素の合金鋼を用いているため、冷間鍛造により素材から一気にカムピース形状に成形することが可能となり、カムピースの輪郭形状の冷間成形と内径形状の冷間成形を連続した工程で行うことができるようになって、工程数の削減と工程間在庫の解消によるコストダウンが可能となる。

【0036】その上、冷間鍛造処理後に浸炭焼入れ処理を施して必要な表面硬さを確保するようにしているため、浸炭焼入れが施されたカムピースは高炭素鋼の焼入れ品と比べてその硬さ分布が異なり、内部硬度は低いものとなる。そして、カムピースは相手側となるシャフトにマンドレルを挿入して捻接結合する際に衝撃荷重を受けることになるが、上記のようにカムピースの内部硬さが低いことが有利に作用し、結果として耐衝撃性が向上して捻接時のカムピースの割れの発生を防止することが可能となる。

【0037】請求項8、9に記載の発明によれば、上記各工程での成形がカム頂部側を下向きにした状態でそれぞれ冷間処理として多段式鍛造機にて行われるようになっていて、さらに請求項10に記載の発明によれば、各工程間での中間成形体の搬送もカム頂部側を下向きにした状態で行われるようになっていることから、前工程から搬送されてきた中間成形体を後工程の彫り込みに挿入さえすれば、中間成形体のカム頂部とその成形を司る彫り込みのカム頂部相当部とが直ちに合致することになる。その結果、彫り込み内での中間成形体のいわゆる転がり現象を防止できることはもちろんのこと、彫り込みに対して中間成形体の位置がカム頂部側に偏っていて、実質的に材料配分が早い時期からカム頂部側に偏っていることにほかならないから、カム頂部側での材料充満が一段と促進されて、機能上最も重要なカム頂部側での偏肉や欠肉を確実に防止して、鍛造品質の向上に大きく貢献できるようになる。

【0038】請求項11に記載の発明によれば、後工程のダイスの彫り込みに対して中間成形体を押し込み挿入する際に、予めカム頂部を彫り込み側のカム頂部相当部に合致させた上で押し込み挿入するようにしたものであり、また請求項12、13に記載の発明によれば、その具体的手段として、前工程側の彫り込みの重心位置に対して後工程側の彫り込みの重心位置を所定量だけ予め上方側にオフセットさせておくか、もしくは前工程から後工程に中間成形体を搬送する過程でその中間成形体の重心位置を所定量だけ下方に移動させるようにしたものであるから、その中間成形体のカム頂部と彫り込み側のカム頂部相当部が自律的に合致するようになり、カム頂部側での材料充満効果が一段と促進されて、カム頂部側での偏肉や欠肉をより確実に防止できる利点がある。

【0039】請求項14に記載の発明によれば、カムピースの形状と略相似形の断面形状をもつ異形状で且つ長尺なコイル材を多段式鍛造機に直接供給するにあたり、その切断後の素材の向きが上記カム頂部を下向きとした姿勢と一致するように予め考慮したものであるから、カム頂部側への材料充満がより一層促進されて、カム頂部側での偏肉や欠肉を防止しつつその形状精度が一層安定化するほか、素材として切断材を使用した場合と比べて鍛造工程数の削減と製造コストの低減が図れるよ

うになる。

【0040】

【発明の実施の形態】図1～9は本発明に係るカムピースの製造方法のより好ましい実施の形態を示している。

【0041】図1の(A)に示すように、冷間鍛造、浸炭焼き入れおよび組立工程を経て組み立てられることになる組立式カムシャフトについて、本実施の形態ではそのカムピース1の素材Wとして低炭素鋼もしくは低炭素の合金鋼（例えば、炭素Cの含有量が0.2%のSCr420H材）を用いることを前提とする。低炭素の材料は冷間での成形性が良いため、冷間鍛造により素材Wから一気にカムピース形状に成形することが可能となる。その結果、後述するようにカムピース1の輪郭形状を成形するための冷間成形と内径形状を成形するための冷間成形を連続の工程で行うことができるようになり、工程数の削減と工程間在庫の解消によるコストダウンが可能となる。

【0042】冷間鍛造の工程はさらに図1の(B)、(C)のように細分化されており、中実円筒状（円柱状）の素材Wをもってカムピース1の形状に成形する輪郭成形工程と、カムピース1の厚み寸法を整える矯正工程と、カムピース1の中央部に形成されるシャフト穴2の打ち抜き加工を行うピアス工程と、シャフト穴2の内周面について例えば穴スプライン形状の如き異形状に仕上げ成形する内径しごき工程とが含まれている。これだけの工程数であれば輪郭成形工程から内径しごき工程までの全ての工程を高速の多工程鍛造プレス機（多段式冷間鍛造機）にて連続成形することが可能となり、サイクルタイムの短縮化による生産性の向上とコストダウンが図れるようになる。

【0043】輪郭成形工程は、さらに一次成形工程と二次成形工程とに分かれており、一次成形工程では円柱状の素材Wをその軸心方向に据え込んで長円形状もしくは略小判状に据え込み変形させるとともに、その変形した途中工程形状であるところの中間成形体W1の上面すなわちカムピース1の一方の側面に相当する部分を二つの平面5a、5bを含む形状に有段成形して、後述するようにカムピース1のカム頂部（ノーズ部）3となるべき部分に向かってその肉厚が漸増する形状に成形する。

【0044】また、二次成形工程では、一次成形工程にて有段成形された中間成形体W1をさらに偏平化させるべく据え込んで輪郭形状をカムピース1の形状に整えるとともに、シャフト穴2となるべき部分に凹陷部4を印圧成形する。この工程での凹陷部4の成形は必ずしも必要なものではないが、素材肉の分配を早い時期から行って後述するピアス加工の際にスクラップとなるべき領域を可及的に少なくする上で有効に作用する。

【0045】この二次成形工程をもって輪郭成形工程を終えた場合に中間成形体W1の一部にはなお欠肉Qが発生する可能性がある。そこで、輪郭成形工程に続く矯

正工程では中間成形体W1の輪郭形状をさらに整えながら厚み方向に据え込んで、欠肉Qがなくなるように矯正する。

【0046】ピアス工程では、中間成形体W1のうち先に凹陷部4が形成された部分を、これを下穴としてせん断工法にて打ち抜いてシャフト穴2を成形する。さらに、内径しごき工程ではシャフト穴2についてマンドレルの圧入をもってしごき加工を施し、シャフト穴2の内周面を穴スプラインの如き形態で凹凸形状に仕上げる。

【0047】図1では素材Wとして円柱状のものを示しているが、例えば図2に示すように製品であるカムピース1の輪郭形状と相似形をなすいわゆる異形状の素材Wcを用いることがより望ましい。このような異形状の素材Wcは例えば図3に示すような連続鑄造法によって成形することが可能である。すなわち、保持炉11内の溶湯を水等による冷却装置12にて強制冷却されたダイ13を通して引き抜き装置14にて引き抜くことで異形状の棒状素材Wnとして鑄造成形される。なお、この種の技術は例えば特開平5-104209号公報等で公知である。

【0048】素材W（またはWc）は円柱状のものであるか異形状のものであるかにかかわらず予め前工程にて棒状素材から所定寸法に切断し、これを図1に示した輪郭成形工程に投入することも可能であるが、棒状素材を直接多工程鍛造プレス機に供給してその初期工程にて切断し、そのまま後工程である輪郭成形工程に投入するのが工程短縮および中間在庫解消の上で望ましい。また、上記異形状の素材Wcの成形法としては、上記連続鑄造法によって直接成形する方法のほか、丸棒状に鑄造しながら引き抜き成形したものをロール成形等にて異形状にし、これを切断工程に投入するようにしてもよい。

【0049】上記のように素材Wcを予め異形状とした場合には、鍛造時におけるカムピース1の長径方向への材料移動が少なく済むため、長径と短径との差が大きいカムピース1すなわちカムリフト量が多いもしくはカム頂部3が一段と尖ったカムピース1の成形を容易に行えるほか、輪郭成形工程内での工程数を少なくする上でも有効に作用する。しかも、素材形状から必要とするカムピース1の形状となるまでの変形量が少なくなることによって金型の負荷が軽減されて、その長寿命化の上でも有利となる。したがって、一次成形工程での変形量を一段と小さくすることができ、カムピース1の大きさ等によっては実質的に図1の一次成形工程と二次成形工程とを一緒にして輪郭成形工程を一工程化することも可能である。

【0050】図2の（A）に示した異形状の素材Wcはカム頂部（ノーズ部）3に相当する部分の円弧状部としての曲率半径R0、カム頂部3の開き角 θ 0、および長径D0と短径d0との比D0/d0により定義される

が、それらの曲率半径R0および開き角 θ 0の値のほかD0/d0の値のそれぞれが、同図（B）に示すように最終製品形状であるカムピース1のカム頂部3の曲率半径R1、開き角 θ 1、および長径D1と短径d1との比D1/d1と同じになるのが望ましい。ただし、成形限界や設備能力限界等の成形上の制約から全ての条件を満たし得ない場合には、（1）カム頂部の曲率半径R0、（2）カム頂部の開き角 θ 0、（3）長径Dと短径dとの比D0/d0の順に優先順位として、素材Wcの形状と製品であるカムピース1の形状とを一致させるようにする。なお、ここでの優先順位は、図1の輪郭成形工程において円柱状の素材Wからカムピース1を成形する場合の形状精度出しの難しさの順位と対応している。

【0051】ここで、上記カム頂部3の開き角 θ とは、図2に示すようにカムピース1のベースサークルとこれよりも小さなカム頂部3の円弧部とを両者が共有する二つの接線にてつなげた形状の接線カムを想定した場合に二つの接線同士となす角度をいう。

【0052】図1の輪郭成形工程にて一次成形を終えた素材Wの途中工程形状すなわち中間成形体W1は、図4にも示すように、製品であるカムピース1の一方の側面に相当する面のうちカム頂部3側に相当する部分5aとそれと反対側の部分5bとが他方の側面と平行でありながらカム頂部3側の部分5aの方が高くなるようにそれら二つの平面5a、5bの間に段差を有した形状となっていることにより、中間成形体W1としての厚み寸法がカム頂部3側に向かって漸増する形状となっている。この思想を先に述べた異形状の素材Wcに適用した場合、図5に示すように素材Wcの途中工程形状である中間成形体W1と製品たるカムピース1のそれぞれの同一角度 α° での断面積が共に同じであることを意味している。

【0053】上記カムピース1のような非対称で且つ一方にボリュームが偏っている製品形状に対し、その中間成形体W1の形状として厚み方向で素材ボリュームを確保し、後から厚み寸法を徐々に均一化しながらカム頂部3に相当する部分に材料を寄せて充満させる。こうすることにより、材料の充満がとかく不十分となりやすいカム頂部3側への材料の流れもしくは塑性流動を促進して、一段とカム頂部3の尖ったカムピース1の成形が可能となるとともに、欠肉等による不良率が大幅に改善される。もちろん、材料の流動が促進されることによって成形に要する荷重が軽減されて、金型の長寿命化にも寄与することになる。

【0054】また、上記のように素材WまたはWcを元形状とする中間成形体W1が二つの平面5a、5bを含む段差を有した形状となっていると、一次成形工程に続く二次成形工程での中間成形体W1の姿勢が安定化し、特に欠肉の発生防止に有効に作用する。例えば、図6に示すように、中間成形体W1が互いに平行な二つの面5

a, 5bを含む段差を有した形状となっていると、ダイス6とパンチ7とで据え込む二次成形の際に断面形状に正しく塑性変形して欠肉等の発生防止の上で有利にはたらくのに対して、互いに平行な二つの面5a, 5bを含む段差を有していない場合には、図7に示すように成形途中で中間成形体W1の転び現象が生じて断面台形状もしくは菱形状に変形してしまい、欠肉Q等の発生が余儀なくされる。

【0055】図1に示した輪郭成形工程の二次成形工程において凹陥部4を成形しているのは、カム頂部3となるべき部分に積極的に材料を寄せるとともに、後工程でのピース加工の際に穴あけの起点となる下穴として機能させるためである。その一方で、凹陥部4を同時成形すると、その周辺部での材料隆起に伴い厚みの不均一さの発生が不可避となる。そこで、輪郭成形工程に続く矯正工程はこの厚みの不均一さを矯正するために行われる。

【0056】ピース工程において、シャフト穴2を打ち抜き成形した後に、内径しごき工程にてシャフトと同一断面形状のピン状のマンドレル等をシャフト穴2に挿入してしごき加工を施すことにより、シャフト穴2を穴ス

ブラインのごとき形状に仕上げる。これにより、図8に示すような製品としてのカムピース1を得る。

【0057】こうして塑性加工を終えたカムピース1に図1に示したように浸炭焼入れを施し、必要な表面硬さを確保する。すなわち、先に述べたように素材WまたはWc自体が高炭素鋼と異なり表面の炭素量が不足しているので、後工程での浸炭処理が必要となる。浸炭焼入れが施されたカムピース1は、図9に示すように高炭素鋼の焼入れ品と比べてその硬さ分布が異なり、内部硬度は低いものとなる。

【0058】カムピース1は最終的には相手側となるシャフトと組み合わされることになるが、そのシャフトにマンドレルを挿入して拡張(拡張)結合する際に衝撃荷重を受け、その入力組み付け時のカムピース1の割れの原因となる。この際に、上記のようにカムピース1の内部硬さが低いことが有利に作用し、耐衝撃性が向上して拡張時のカムピース1の割れの発生を防止することが可能となる。特に、素材WもしくはWcとして予めホウ素(B)を添加することにより衝撃強度を向上させた材料を用いると、上記の拡張処理時の割れ防止の上で一段

と有利となる。

【0059】図10以下の図面は上記の製造方法のもとの多工程鍛造プレス機の具体的加工手順を示している。

【0060】図10は上記輪郭成形工程のうちの一次成形工程を示しており、ロックアウトピン21を有するダイス22の中に図11に示すような異形状の素材Wcを挿入した上でパンチ23により据え込む。これにより、素材Wcの途中工程形状すなわち中間成形体W1は、図12にも示すように製品であるカムピース1の一

方の側面に相当する面のうちカム頂部3側に相当する面5aとそれと反対側の面5bとが他方の側面と平行でありながらカム頂部3側の面5aの方が高くなるように段差を有した形状となり、結果として中間成形体W1としての厚み寸法がカム頂部3側に向かって漸増する形状に鍛造成形される。

【0061】図13は輪郭成形工程のうちの二次成形工程を示しており、ロアパンチ24を有するダイス25の中に図12に示した中間成形体W1を挿入した上でアッパーパンチ26により据え込み、二つの面5a, 5b同士の段差をなくすように平坦化するとともに、両面に凹陥部4a, 4bを印圧成形する。これによって図14に示すような中間成形体W1を得る。なお、凹陥部4a, 4bは先に述べた穴スブライン形状のごときシャフト穴2の下穴として機能することから、ここではその形状に近付けるために多角形の形状にしてある。

【0062】図15は輪郭成形工程に続く矯正工程を示しており、ダイス27内にてロアパンチ28とアッパーパンチ29とで図14に示した中間成形体W1を加圧拘束して形状の矯正を行う。その結果として、図16に示すようにより形状精度が高められた中間成形体W1を得る。

【0063】図17はピース工程を示しており、ダイス30内にて図16に示した中間成形体W1に対し、ピースパンチ33とアッパーパンチ32とのせん断作用に基づきシャフト穴2を打ち抜き成形する。なお、ピースパンチ33の先端は軸スブライン形状に形成されており、図18に示すように中間成形体W1の中央部がシャフト穴2として打ち抜かれることでスクラップSが発生す

る。

【0064】図19は内径しごき加工工程を示しており、ダイス34内にて図18に示した中間成形体W1に対し、内径しごき加工用の軸スブライン形状のカウンターパンチ37をシャフト穴2に圧入して、そのシャフト穴2を穴スブライン形状の正規形状に仕上げる。その結果として、図20に示すようなカムピース1が得られることになる。なお、図19に示したカウンターパンチ37に代えて図21に示したカウンターパンチ47を用いることもできる。

【0065】図22以下の図面は本発明の第2の実施の形態を示す図であり、図1の(B), (C)に示した各工程での成形をいわゆる横打ち式の多段式冷間鍛造機(コールドフォーマー)にて行うようにした場合の例を示している。

【0066】多段式冷間鍛造機50は、図1のほか図2に示すように、ボルスタ51を主体として、コイル材から図2に示すような異形状の素材Wcを切断する切断工程S1と、同じく輪郭成形工程の一次成形工程S2および二次成形工程S3と、矯正工程S4、ピース工程S5および内径しごき工程S6、およびワーク排出工程

S7とを有している。なお、図1の(B)、(C)の幾つかの工程を経ながらカムピース1としての完成度が高まるのに併せてその外径寸法が徐々に大きくなるように予め考慮されている。

【0067】切断工程S1には、図22の紙面と直交方向から供給されるコイル材（コイル材そのものについては後述する）を図2のような異形状の素材Wcに切断するカッター52と切断後の素材Wcを把持するグリッパ53が設けられている一方、一次成形工程S2、二次成形工程S3、矯正工程S4、ピアス工程S5および内径しごき工程S6にはそれぞれにダイス54が設けられている。また、最終のワーク排出工程S7には図22の紙面と直交方向から出役するワーク排出パンチ55が設けられている。そして、この多段式冷間鍛造機50は図10、13、15、17、19におけるダイスとパンチとの対向軸線方向を水平にしたものと理解することができるから、ボルスタ51に対して水平方向から接近離間動作する図示外のラムには各ダイスに対向するパンチが設けられている。

【0068】ボルスタ51の上方には、各工程S2～S6で成形された中間成形体W1を次工程に順次搬送するための搬送装置56が設けられている。この搬送装置56は、エアシリンダあるいはサーボモータ等を主体とする駆動ユニット57の作動に基づいて水平往復移動するスライダ58に、中間成形体W1もしくはカムピース1を把持するための合計5個のグリッパ59A～59Eを装着したもので、各グリッパ59A～59Eは対応するダイス54の前面側にこれと干渉しないように位置しているとともに、スライダ58の往復動ストロークおよびグリッパ同士の間隔は各工程S2～S7間ピッチと等しくなるように設定してある。なお、この種の搬送装置を備えた多段式鍛造機は例えば特開平11-47877号公報等で公知である。

【0069】そして、図22の状態を搬送待機状態とすると、後述するように搬送待機状態にある各グリッパ59A～59Eには各工程S2～S6での成形を終えた中間成形体W1が把持され、その後にスライダ58の往復動作に基づき各グリッパ59A～59Eが一斉に次工程に移動することで各グリッパ59A～59Eに把持されている中間成形体W1が次工程へと搬送される。各グリッパ59A～59Eはその次工程での成形が終了するまでスライダ58とともに次工程で一時待機し、成形が終了すると再びスライダ58の復動動作に基づき搬送待機状態すなわち図22に示す位置まで戻ることになる。

【0070】なお、切断工程S1にあるグリッパ53も上記の各グリッパ59A～59Eと同期作動し、後述するように切断工程S1のカッター52にてコイル材から切断された異形状の素材Wcを把持した上でこれを一次成形工程S2まで搬送する役目をする。

【0071】各グリッパ53および59A～59Eは図

23に示すように揺動開閉自在な一対の爪片60を備えていて、グリッパ本体61と各爪片60とが板ばね62にて連結されていることにより、各爪片60には板ばね62のばね定数によって決定される把持力によって中間成形体W1もしくはカムピース1を把持するようになっている。各爪片60における把持面の開口縁には比較的大きなC面取り（面取り部を符号63で示す）が施されていて、後述するように爪片60が把持している中間成形体W1よりも所定量だけ大きなパンチが進入してきたときには、そのパンチをもって爪片60を押し広げながら中間成形体W1を押し出すのを許容するようになっている。

【0072】ここで、一次成形工程S2から内径しごき工程S6へと順次加工が進むのに伴い、その都度中間成形体W1としての輪郭形状が少しずつ大きくなるように予め設定されており、したがって、各グリッパ59A～59Eは上記の輪郭形状の違いに対応できるだけの把持代を予め持たせてある。

【0073】したがって、このような多段式冷間鍛造機50の構造によれば、例えば一次成形工程S2を代表例として図24を参照しながらその詳細を説明すると、同図(A)に示すように、先のスライダ58の往復動作に同期して切断加工後の異形状の素材Wがグリッパ53に把持された状態で一次成形工程S2のダイス54の前面位置まで搬送されて、その位置に位置決めされる。すなわち、ダイス54側の彫り込み（インプレッション）64とグリッパ53に把持されている素材Wの輪郭とが一致するように位置決めされる。そして、その一次成形工程S2のパンチ65が前進動作すると、パンチ65はグリッパ53の爪片60を押し広げながら素材Wを彫り込み64内に押し込んで、同図(B)に示すように図10と同様の形態で一次成形を施すことになる。

【0074】一次成形が終了すると同図(C)に示すように最初にパンチ65が後退し、次いでそれまで一次成形工程S2で待機していたグリッパ53を含む全てのグリッパ59A～59E（グリッパ59A～59Eはいずれも素材Wcもしくは中間成形体W1を把持していない）がスライダ58の復動動作により一斉に元の位置に戻る。これにより、一次成形工程S2にはグリッパ53に代わってグリッパ59Aが位置することになる。この状態で同図(D)に示すようにノックアウトパンチ（ノックアウトピン）66が前進動作して、彫り込み64内の中間成形体W1を押し出しながら、なお且つその中間成形体W1をもってグリッパ59Aの爪片60を押し広げて一次成形後の中間成形体W1をグリッパ59Aに把持させる。グリッパ59Aが中間成形体W1を把持するとノックアウトパンチ66は直ちに元の位置に戻る。

【0075】この状態は、グリッパ59Aが入れ替わっている以外は同図(A)の状態と同じであり、したがって、搬送装置56のスライダ58が次の搬送動作を行う

時にはそのグリッパ59Aに把持されている一次成形終了後の中間成形体W1は次の二次成形工程S3へと搬送されることになる。

【0076】このような一連の動作は、一次成形工程S2以外の各工程S3～S6においても基本的に同様であって、全ての工程S1～S7の動作が同期して且つ並行して行われる。ただし、ワーク排出工程S7においては、図25に示すように各工程S2～S6のノックアウトパンチ66が前進動作するのと同期してワーク排出パンチ67が前進動作して、内径しごき加工を終えたカムピース1（図1参照）をグリッパ59Eから押し出す動作のみが行われる。そして、グリッパ58Eから解放されたカムピースは製品として回収される。

【0077】ここで、各工程S2～S6におけるダイス54の彫り込み64は、図26に示すようにカム頂部3の成形を司ることになるいわゆるカム頂部相当部が下向きとなるように設定されており、同時にこの彫り込み64の姿勢に対して中間成形体W1の姿勢を合わせるべく、先に述べたグリッパ53および搬送装置56による素材Wcもしくは中間成形体W1の搬送姿勢もまたそのカム頂部3側が下向きとなるように予め設定されている。

【0078】したがって、図24に示した一次成形工程S2を例にとって説明すれば、パンチ65による押し出し動作によってグリッパ53から異形状の素材Wcを解放しつつこれを彫り込み64に押し込む際に、図26、27にも示すようにグリッパ53から解放された瞬間に素材Wcはわずかな量 β だけ自重落下し、カム頂部3側が下向きであるためにそのカム頂部3側のプロフィールをもって直ちに素材Wcと彫り込み64のカム頂部相当部とが合致して、いわゆるセルフロケート機能もしくは自動調芯機能が発揮されることになる。

【0079】より詳しくは、図27にも示すように、グリッパ53に把持されていた異形状の素材Wcがパンチ65によって押し出されてその把持力から解放された瞬間に所定量 β だけ自重落下して、直ちにそのカム頂部3と彫り込み64側のカム頂部相当部とが合致して、実質的にカム頂部3側に材料配分が偏った状態のままで彫り込み64の底部側に押し込まれることで一次成形が施されることになる。

【0080】そのため、素材Wcにパンチ65の加圧力が作用するよりもかなり早い時期からカム頂部3側に材料配分が偏っていて、そのカム頂部3側は予め優先して材料（素材肉）が充填していることになり、冷間鍛造であることもさることながら尖鋭状であるがためにとかく材料が充填しにくいとされるカム頂部3側に十分に材料を充填させることができ、特にそのカム頂部3側での偏肉や欠肉の発生を防止して鍛造品質の向上に寄与できるようになる。

【0081】逆に言えば、図28に示すように各ダイス

54における彫り込み64の向きをカム頂部3側が上向きとなるように設定した場合には、素材Wcが自重落下した瞬間に彫り込み64内で素材Wcの転び現象が発生し、材料充填不足のために特にカム頂部3側での偏肉や欠肉が発生しやすくなるのであって、上記実施の形態ではこのような不具合を効果的に解消できる。

【0082】なお、図26、27の挙動は図1、24に示した一次成形工程S2を例にとって説明したが、それ以外の各工程S3～S6についてもその挙動は基本的に同様である。また、異形状の素材Wcに代えて図1に示したような円柱状の素材WをWを使用した場合でも、図29から明らかなように同様にしてカム頂部3側を重視した材料配分を与えることができることは言うまでもない。

【0083】さらに、図30に示すように、例えば先に述べた一次成形工程S2におけるダイス54の彫り込み64と後工程である二次成形工程S3の彫り込み64との関係についてみた場合、前工程である一次成形工程S2から後工程である二次成形工程S3へと中間成形体W1を水平に且つ平行移動させて搬送することを前提としているため、双方の彫り込み64の重心位置Gは互いに一致させてあり、それがために図26、27に示したように中間成形体W1を二次成形工程S3の彫り込み64に押し込む際に所定量 β だけ中間成形体W1が自重落下することになる。

【0084】そこで、図30に示すように、後工程である二次成形工程S3の彫り込み64の重心位置Gを前工程である一次成形工程S2の彫り込み64の重心位置Gに対して所定量 a （ $=\beta$ ）だけ上方に予めオフセットさせておくと、上記の自重落下量 β が相殺されることになる。つまり、図32に示すように一次成形工程S2から搬送されてきた中間成形体W1がグリッパ59Aに把持されている段階で既にそのカム頂部3と彫り込み64側のカム頂部相当部とはその高さ位置が一致していることになり、先のオフセット量 β 分だけの自重落下を伴うことなしに彫り込み64と中間成形体W1との相互関係として、カム頂部3側に材料配分を優先もしくは偏らせた状態とすることができ、中間成形体W1と彫り込み64との相対位置決め精度が一段と向上する。

【0085】ここで、図30に示したように前工程である一次成形工程S2と後工程である二次成形工程S3との彫り込み64、64同士の間上記のようなオフセット量 a を設定しない場合であっても、中間成形体W1の搬送姿勢としてそのカム頂部3側が下向きとなるように設定しておけば、一次成形工程S2から二次成形工程S3への中間成形体W1の搬送過程において上記オフセット量 a と同等分だけ中間成形体W1を積極的に下降（オフセット）させるようにすれば上記と同様の効果が得られることになる。

【0086】これら前工程と後工程との間での彫り込み

64のオフセット量 a ($=\beta$)の設定もしくは搬送過程でのオフセット量 a は、二つの工程が相互に隣接していることになる他の工程S4～S6においても同様に設定されている。

【0087】次に、図22の多段式冷間鍛造機50に供給されることになる異形状の coils 材の好ましい形態について説明する。

【0088】図3に示すような例えば連続鋳造法により成形された棒状素材 W_n は、後工程にて図33に示すようにカム頂部3側とは反対側の面を内側として所定のドラムに巻き取られることで coils 材70とされ、この coils 材70は図34に示すように多段式冷間鍛造機50の前段に配置されるアンコイラー71にセットされる。なお、図33に示すようにカム頂部3側を外側にして棒状素材 W_n を巻き取るのは、カム頂部3側を内側にするに接触面積が小さいために安定性が悪く、また機能上最も重要なカム頂部3を変形させてしまうおそれがあるためである。そして、 coils 材70はアンコイラー71にて巻き戻されながら矯正機72を経た上で多段式冷間鍛造機50に供給されて、図22の切断工程S1のダイスから順次送り出されることになる。

【0089】この場合において、図34に示すように coils 材70の巻き戻し開始位置73が上側になるようにアンコイラー71にセットすると、 coils 材70の始端部ではカム頂部3側が上向きとなってしまう、先に述べたような多段式鍛造に理想とされる姿勢すなわちカム頂部3側が下向きとなるような姿勢と一致しないことになる。したがって、切断工程S1で切断された素材 W_n を一次成形工程S2に搬送するまでの間にその姿勢を反転させる必要が生じることとなって好ましくない。

【0090】そこで、図35に示すように coils 材70の巻き戻し開始位置73が上側になるようにその coils 材70をアンコイラー71にセットするものとし、こうすることにより coils 材70の始端部での姿勢が多段式鍛造に理想とされる姿勢すなわちカム頂部3側が下向きとなるような姿勢と一致させることができるようになる。

【図面の簡単な説明】

【図1】本発明に係るカムピースの製造方法の好ましい実施の形態としてその工程の概略構成を示す説明図。

【図2】異形状の素材と製品形状とを比較した説明図。

【図3】棒状素材を得るための連続鋳造法の概略を示す説明図。

【図4】有段成形した中間成形体の構成説明図。

【図5】途中工程形状である中間成形体と製品形状とを比較した説明図。

【図6】図4、5の中間成形体を用いた二次成形工程の説明図。

【図7】中間成形体に互いに平行な二つの面がない場合

の二次成形工程の説明図。

【図8】図1の内径しごき工程をもって完成したカムピースの説明図。

【図9】浸炭焼入れ処理後のカムピースの硬さ分布を示す特性図。

【図10】図1に示す輪郭成形工程のうち一次成形工程の詳細を示す要部拡大説明図。

【図11】図10の一次成形工程で使用される異形状の素材の説明図。

10 【図12】図10の一次成形工程で得られた中間成形体の説明図。

【図13】図1に示す輪郭成形工程のうち二次成形工程の詳細を示す要部拡大説明図。

【図14】図13の二次成形工程で得られた中間成形体の説明図。

【図15】図1に示す矯正工程の詳細を示す要部拡大説明図。

【図16】図15の矯正工程で得られた中間成形体の説明図。

20 【図17】図1に示すピアス工程の詳細を示す要部拡大説明図。

【図18】図17のピアス工程で得られた中間成形体の説明図。

【図19】図1に示す内径しごき工程の詳細を示す要部拡大説明図。

【図20】図19の内径しごき工程をもって完成したカムピースの説明図。

【図21】図19の内径しごき工程で使用される工具の他の例を示す説明図。

30 【図22】本発明の第2の実施の形態として横打ち式の多段式冷間鍛造機の概略構成を示す正面説明図。

【図23】図22の多段式冷間鍛造機で使用されるグリッパの要部拡大図。

【図24】図22の一次成形工程におけるダイスとグリッパとの間での素材もしくは中間成形体の受け渡し状態を示す断面説明図。

【図25】図22のワーク排出工程での作動を示す断面説明図。

40 【図26】一次成形工程における素材とダイス側の彫り込みとの関係を示す説明図。

【図27】図26の垂直断面での作動説明図。

【図28】図26の素材および彫り込みの向きを逆向きにした場合の説明図。

【図29】図26の異形状の素材に代えて円柱状素材を用いた場合のその素材とダイス側の彫り込みとの関係を示す説明図。

【図30】図22における一次成形工程と二次成形工程の彫り込みの相対位置関係を示す説明図。

50 【図31】図30の彫り込み同士の相対位置関係として上下方向に所定量のオフセット量を設定した場合の説明

図。

【図32】図31の垂直断面での作動説明図。

【図33】異形状の素材として切断される前のコイル材の要部拡大断面説明図。

【図34】アンコイラーに対するコイル材の一般的なセット状態を示す説明図。

【図35】第2の実施の形態で採用されるコイル材のアンコイラーに対するセット状態を示す説明図。

【符号の説明】

1…製品としてのカムピース

2…シャフト穴

3…カム頂部（ノーズ部）

4…凹陥部

4a, 4b…凹陥部

5a, 5b…平面

50…横打ち式の多段式冷間鍛造機

* 64…彫り込み

70…コイル材

71…アンコイラー

73…巻き戻し開始位置

Q…欠肉

R0…円弧状部としてのカム頂部の曲率

S1…切断工程

S2…一次成形工程（輪郭成形工程）

S3…二次成形工程（輪郭成形工程）

10 S4…矯正工程

S5…ピアス工程

S6…内径しごき工程

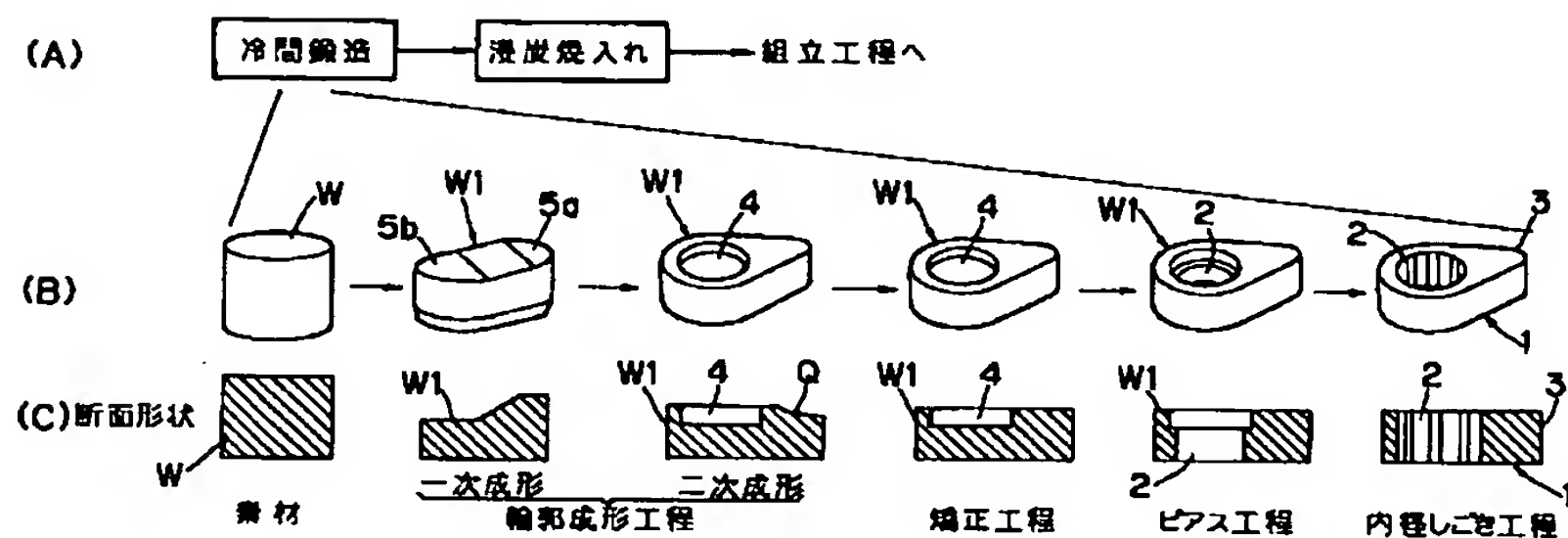
S7…ワーク排出工程

W…素材

W1…中間成形体

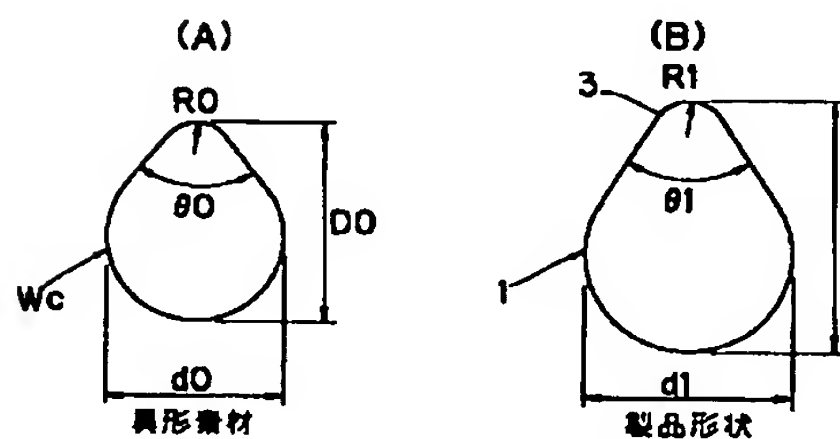
* Wc…異形状の素材

【図1】

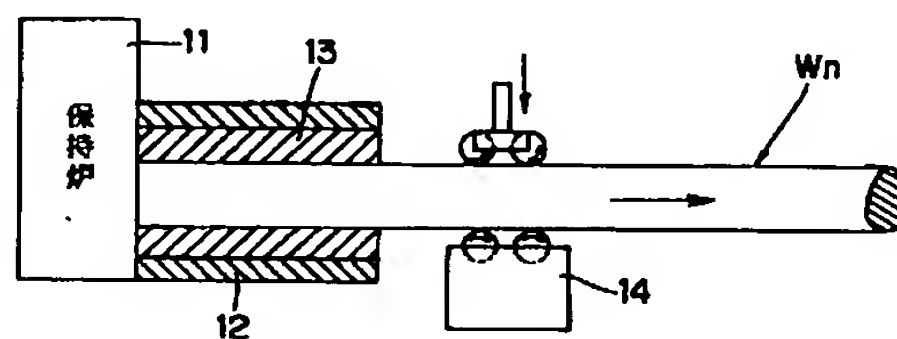


1…製品としてのカムピース
2…シャフト穴
3…カム頂部（ノーズ部）
4…凹陥部
4a, 4b…凹陥部
5a, 5b…平面
Q…欠肉
R0…円弧状部としてのカム頂部の曲率
W…素材
Wc…異形状の素材

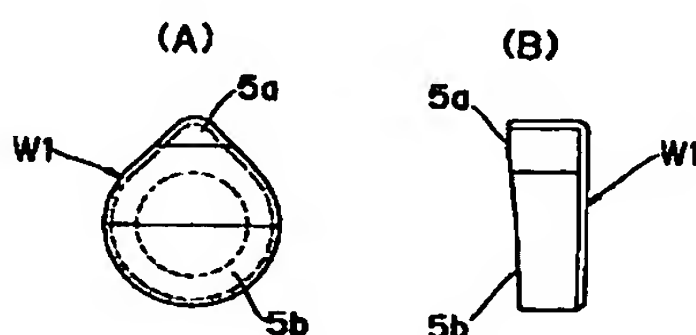
【図2】



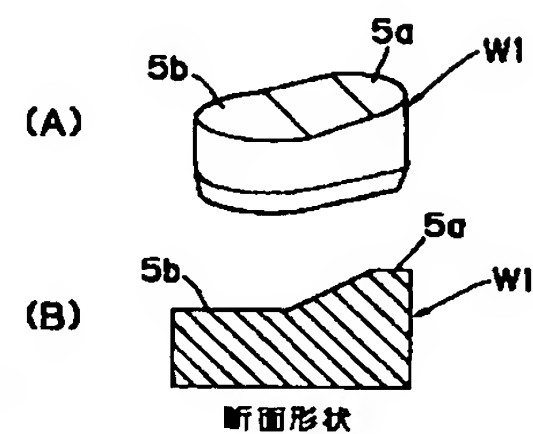
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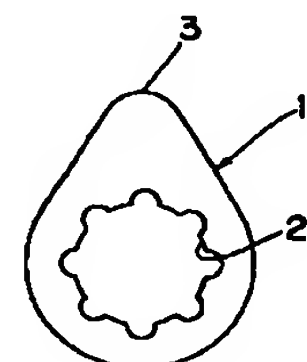
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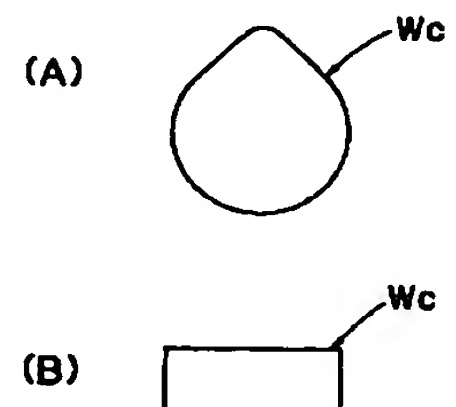
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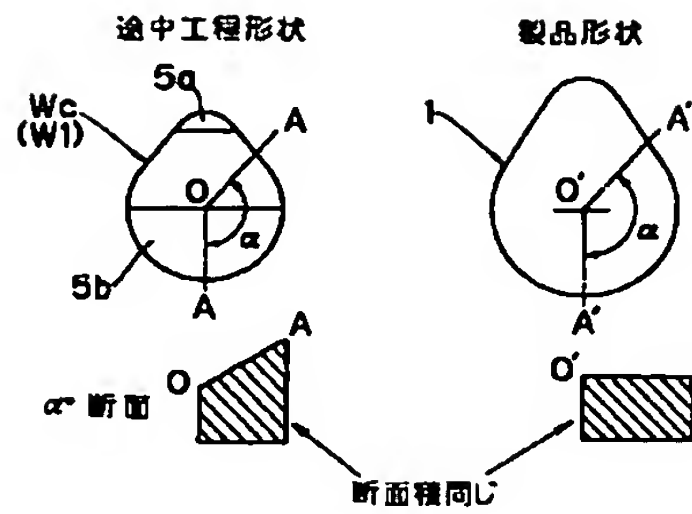
【図8】



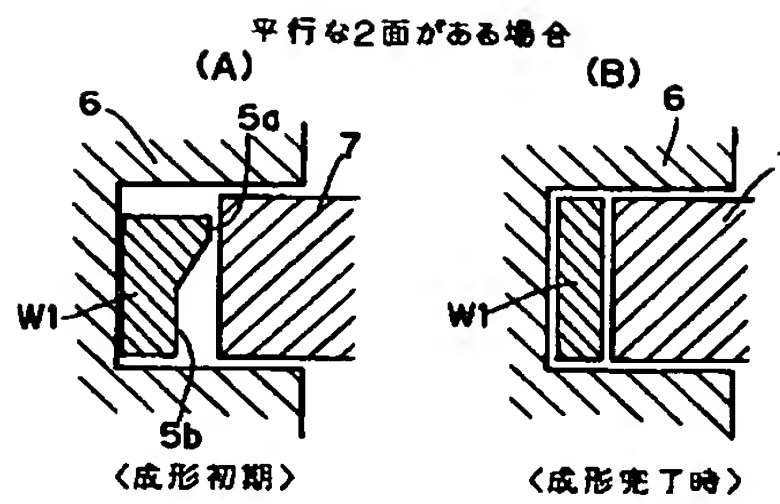
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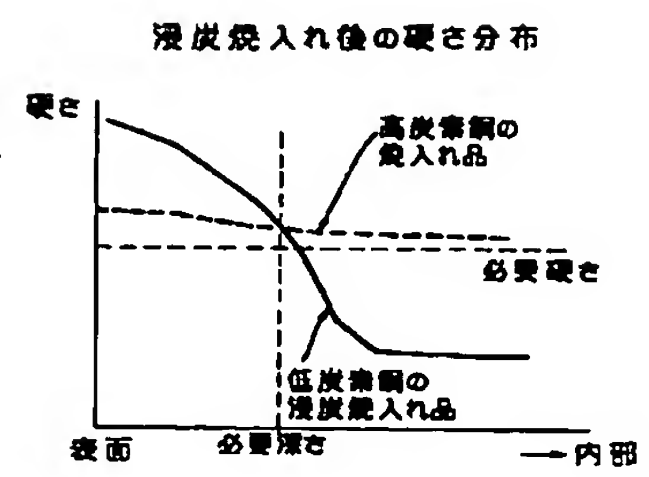
【図5】



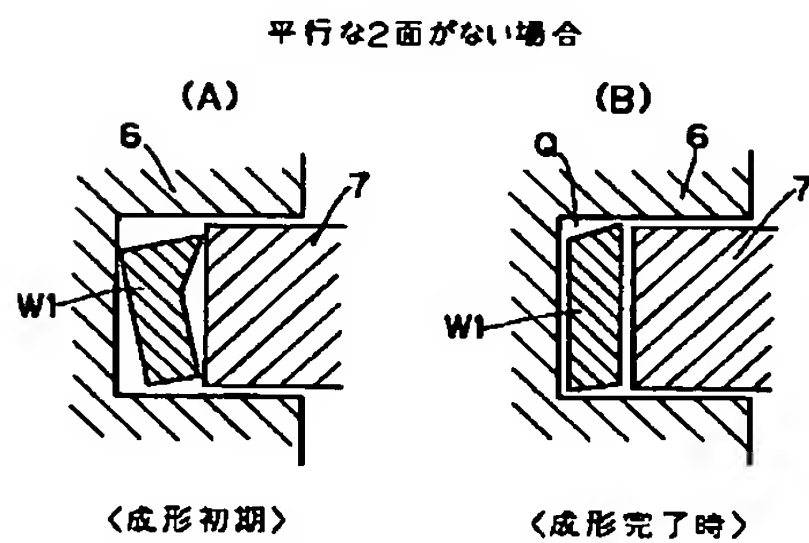
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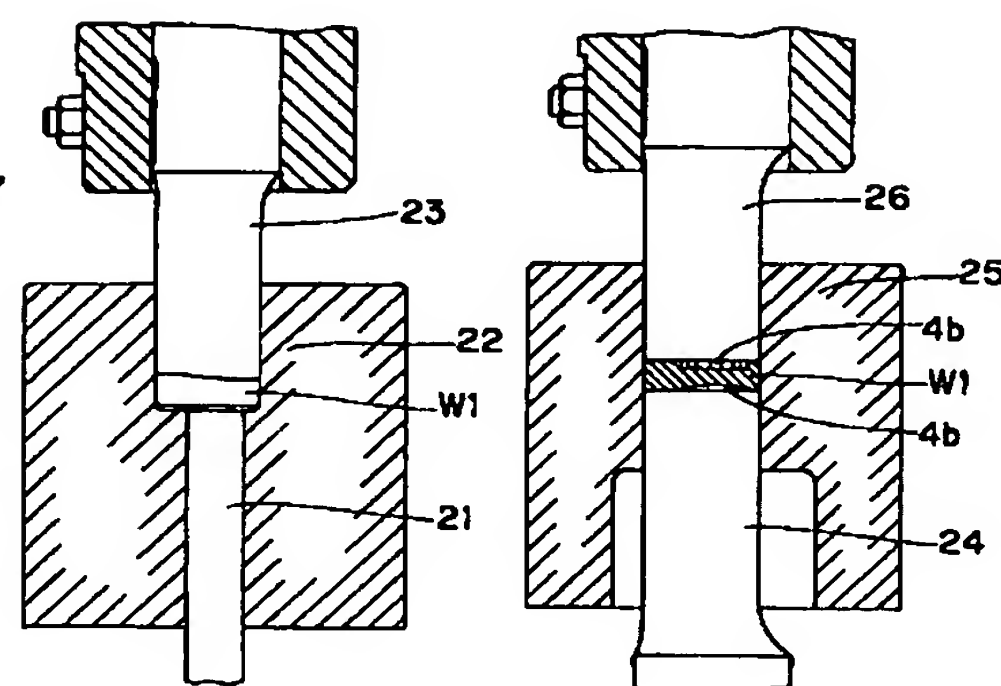
【図9】



【図7】

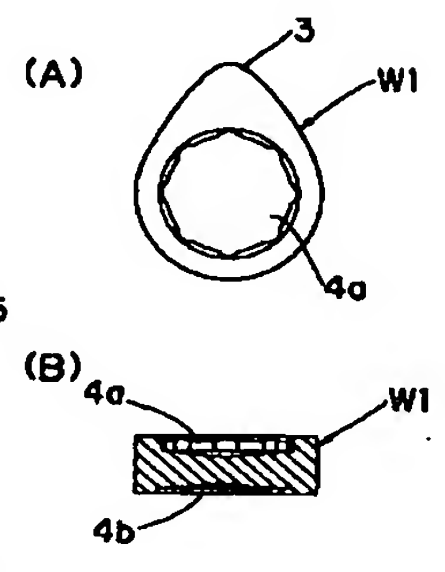


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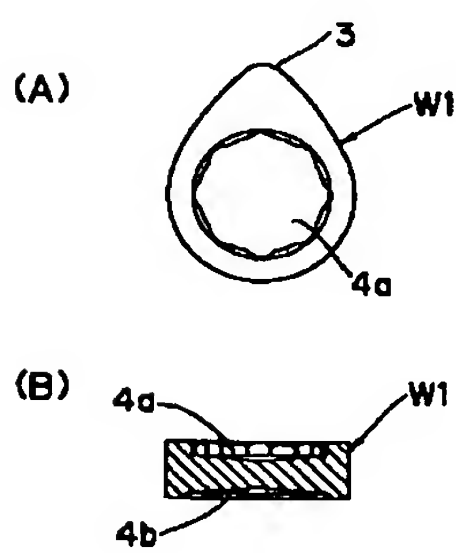


【図13】

【図16】



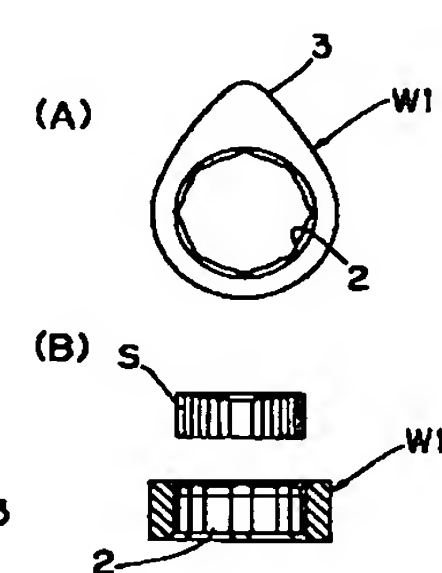
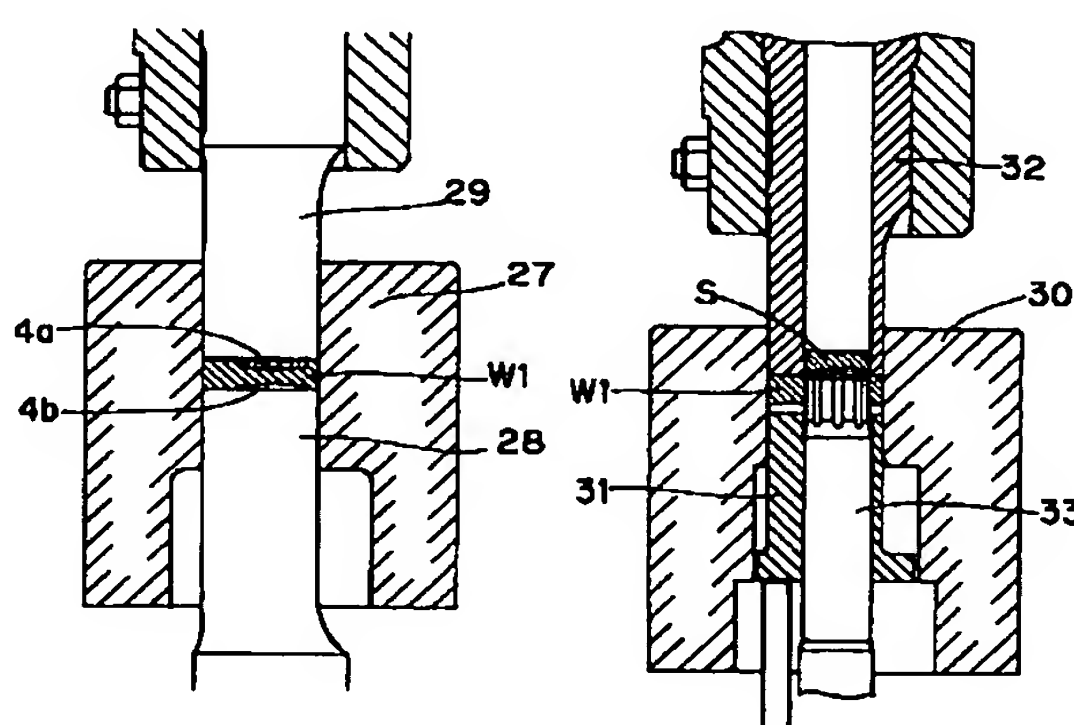
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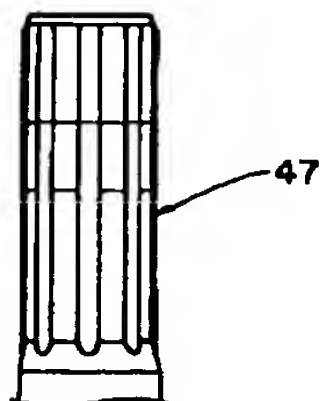
【図15】

【図17】

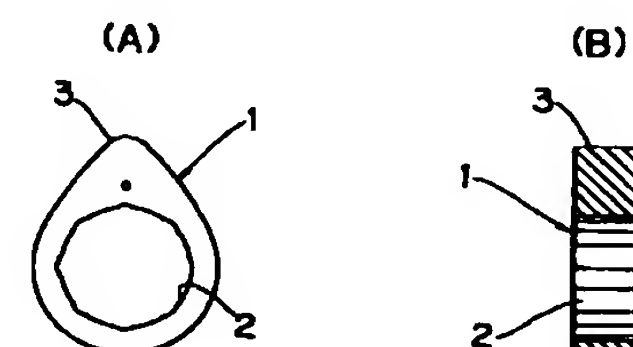
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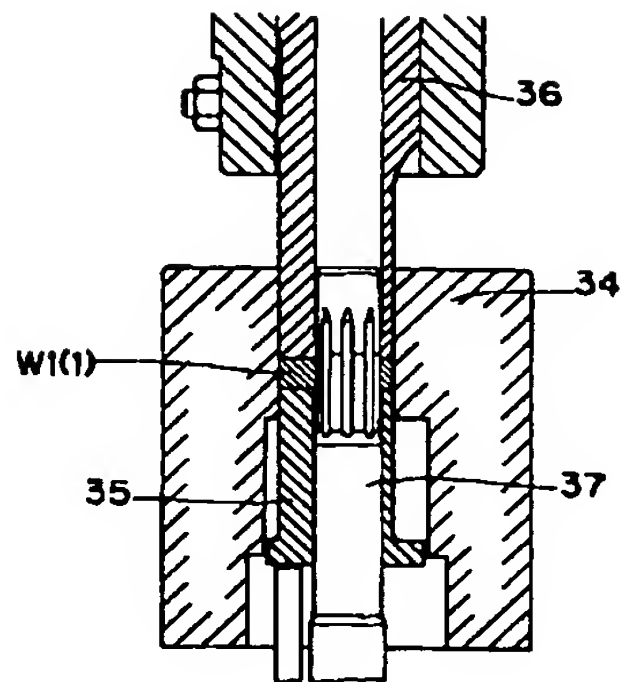
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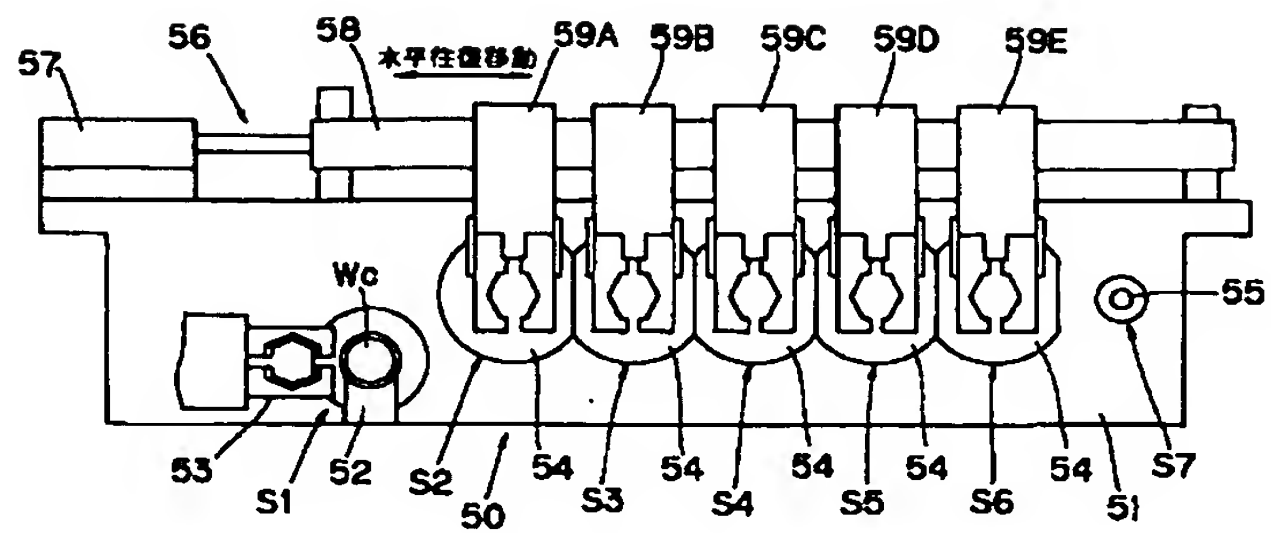
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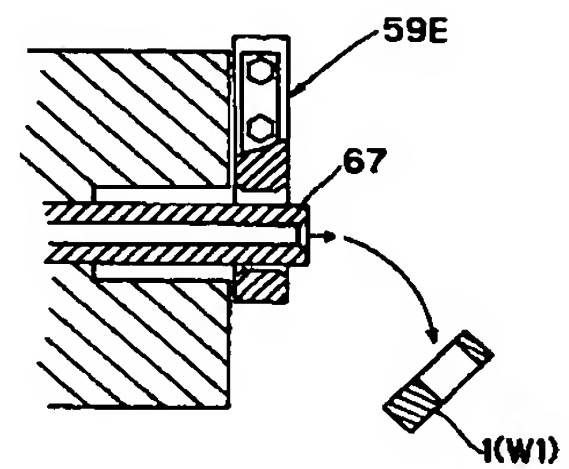
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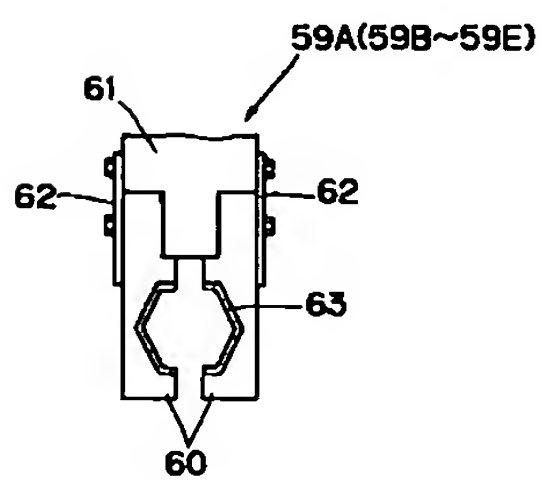
【図22】



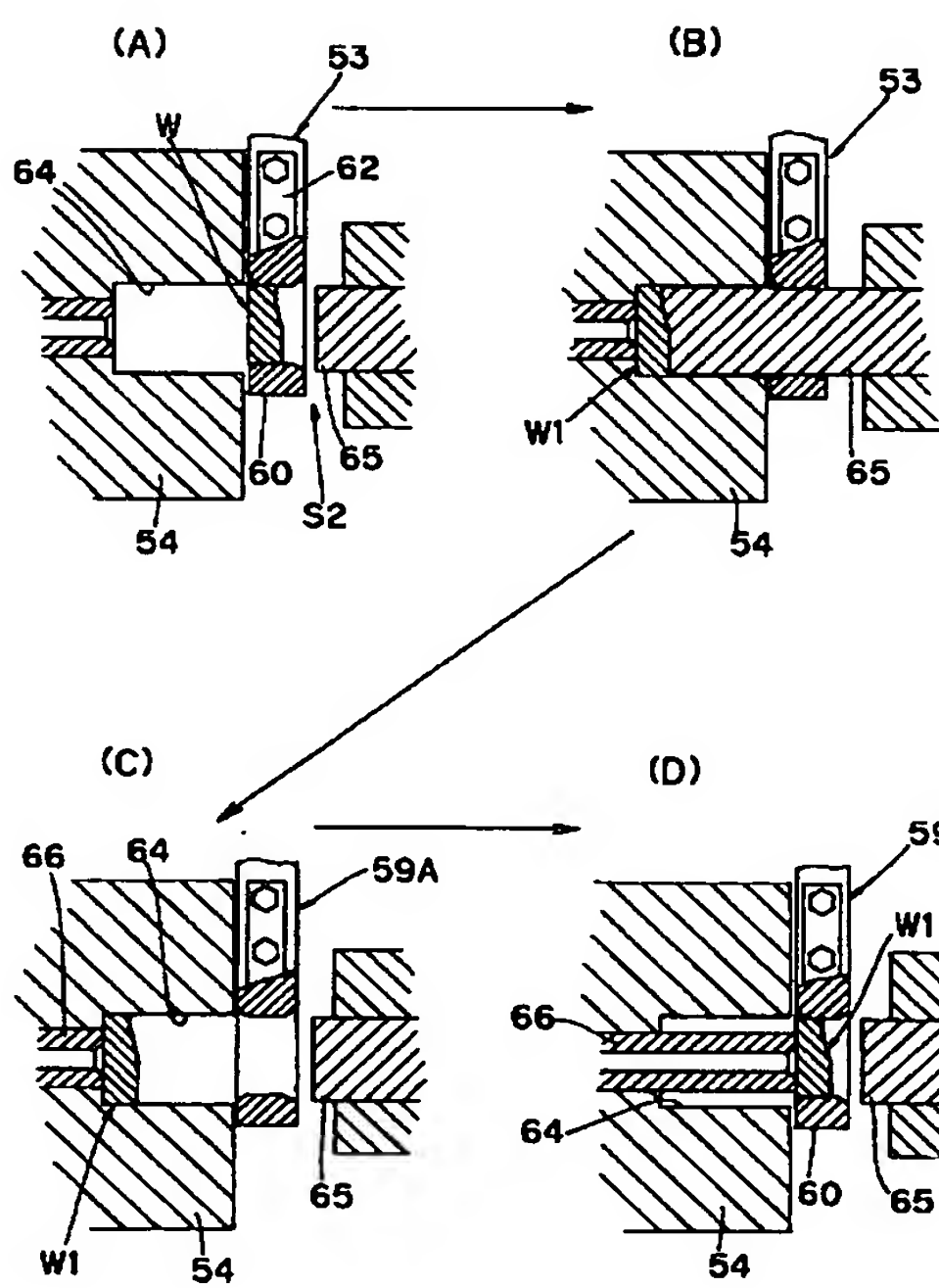
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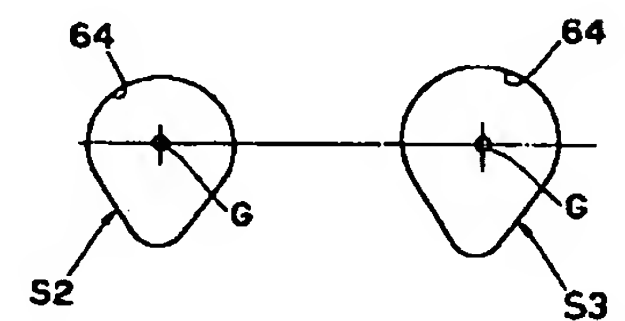
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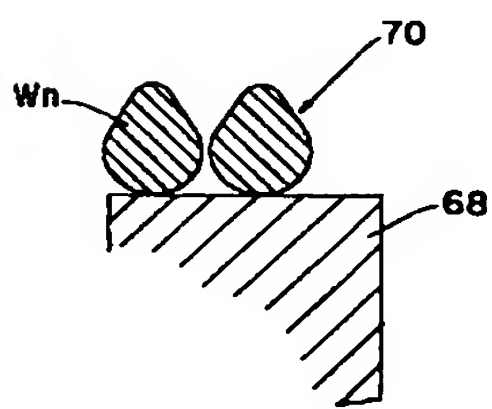
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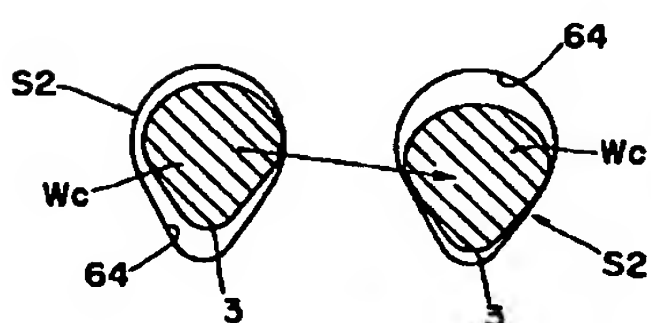
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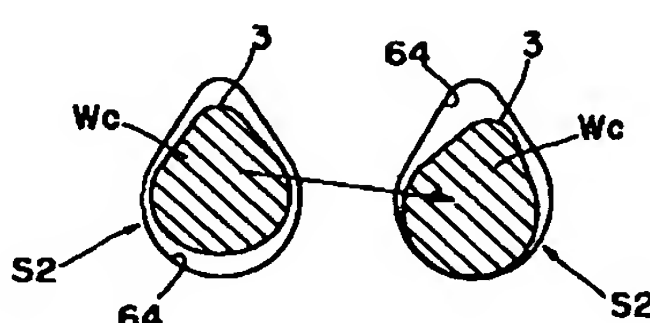
【図33】



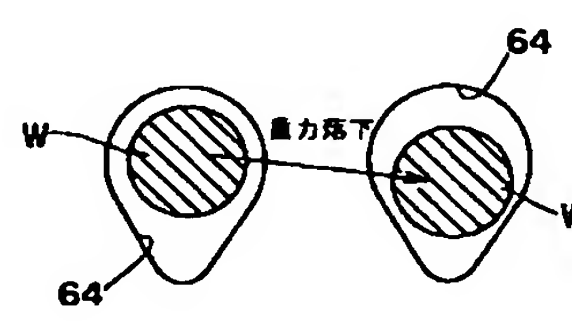
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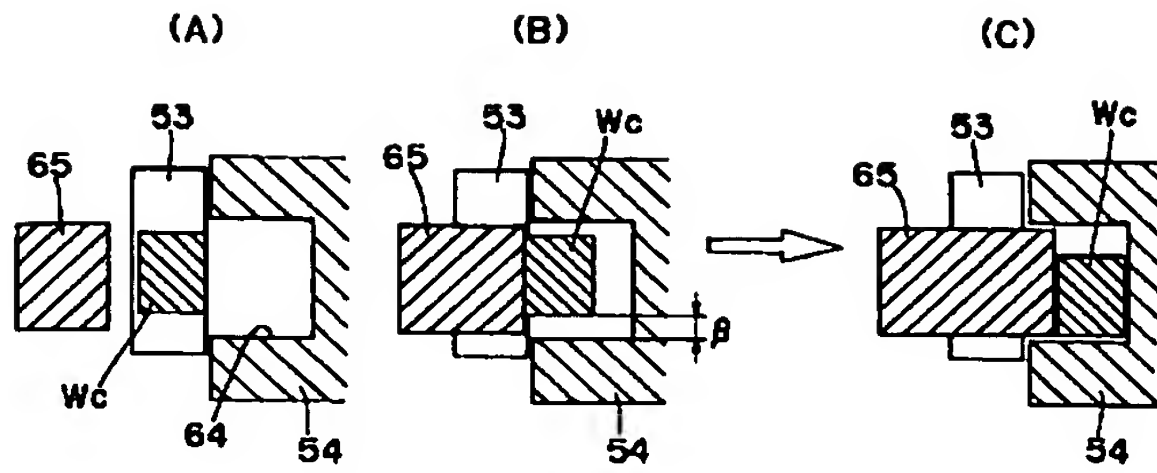
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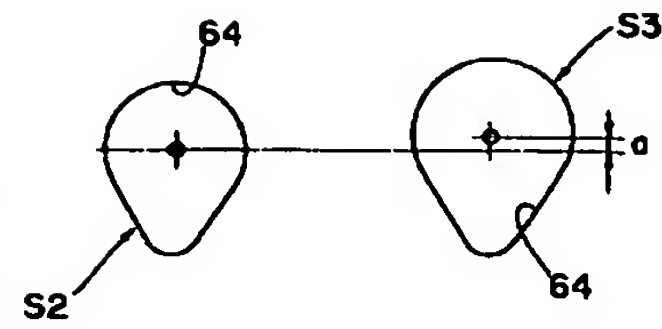
【図29】



【図27】

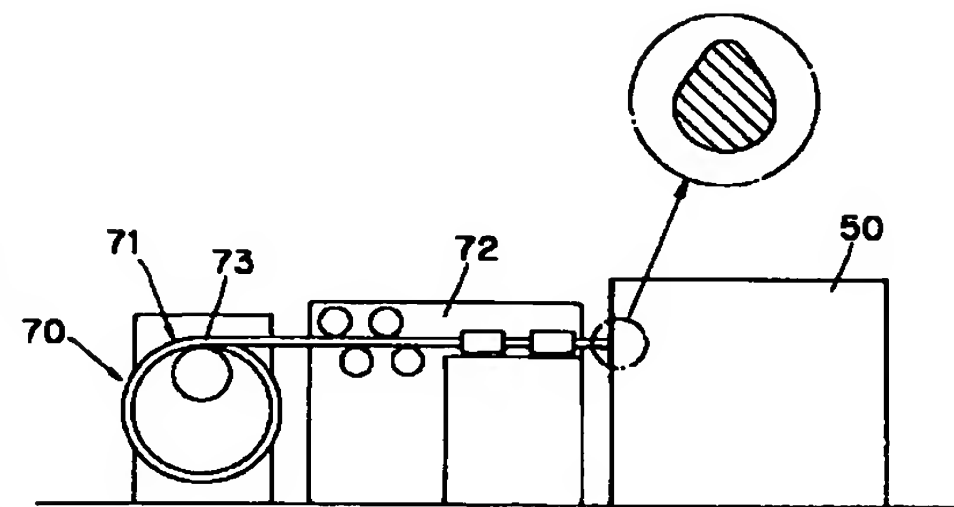
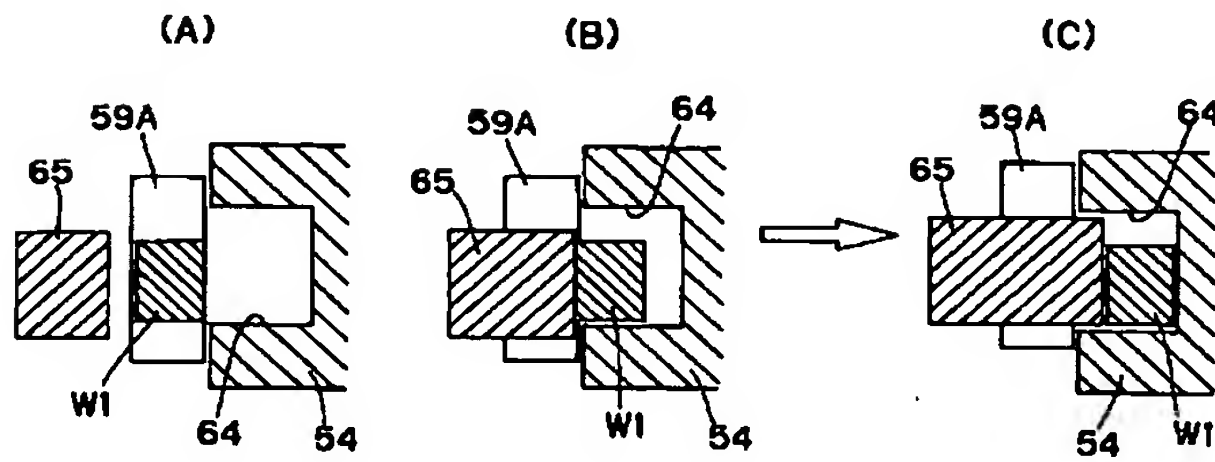


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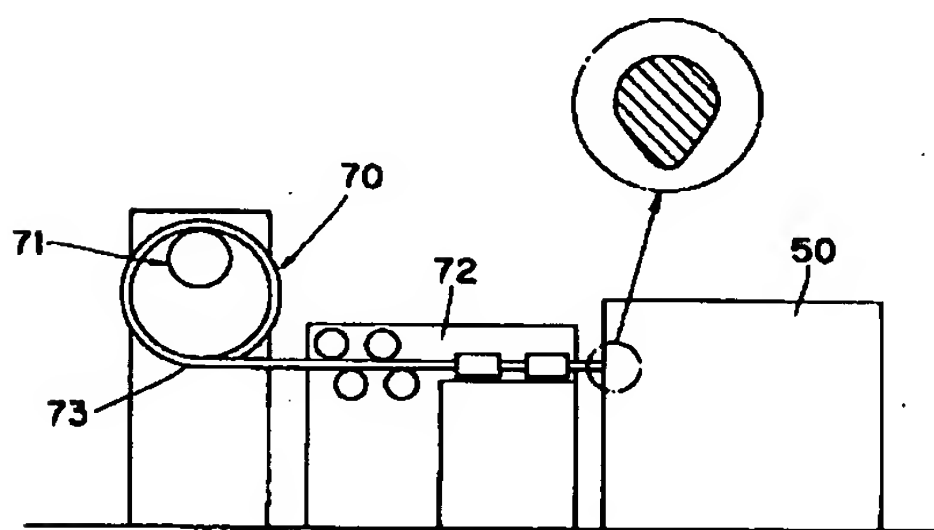


【図34】

【図32】



【図35】



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